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STATE OF ILLINOIS 1968

DEPARTMENT OF REGISTRATION AND EDUCATION

Ground-Water Geology of the Rock Island, Monmouth, Galesburg, and Kewanee Area, Illinois

J. E. Brueckmann
R. E. Bergstrom

REPORT OF INVESTIGATIONS 221

ILLINOIS STATE GEOLOGICAL SURVEY
URBANA, ILLINOIS

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Topographic mapping in cooperation with the United States Geological Survey.

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Ground-Water Geology of the Rock Island, Monmouth, Galesburg, and Kewanee Area, Illinois

John E. Brueckmann and Robert E. Bergstrom

ABSTRACT

Ground water in the Rock Island, Monmouth, Galesburg, and Kewanee area, Illinois, is obtained from (1) sand and gravel aquifers within the glacial drift; (2) shallow bedrock aquifers that are primarily dolomite of the Niagaran Series (Silurian) and the Keokuk-Burlington Limestone (Mississippian); and (3) deep bedrock aquifers, primarily the Ordovician Ancell Group (Glenwood–St. Peter Sandstone) and the Cambrian Ironton-Galesville Sandstone. Most private water supplies are obtained from the shallow bedrock aquifers, whereas the larger municipal supplies generally are obtained from the deep bedrock aquifers. Sand and gravel aquifers are sparsely distributed in the area.

The estimated total pumpage of ground water alone is 16,531,000 gallons per day for the area. This constitutes about 50 percent of the estimated total pumpage of both surface and ground water and serves about 63 percent of the population.

Municipalities now using ground water can probably develop additional ground-water sources to meet increased demands in the future.

INTRODUCTION

The Rock Island, Monmouth, Galesburg, and Kewanee area is located in the northern part of western Illinois (fig. 1) and includes all of Henry, Knox, and Warren Counties and the eastern parts of Rock Island and Mercer Counties. The area is approximately 48 miles wide from east to west and 78 miles long. Farming predominates in much of it, although the principal cities have large manufacturing industries. The area is well served by rail, highway, and river transportation.

Surface water and ground water are used in approximately equal amounts. The Mississippi River is the main source of surface water. Ground water provides many municipal and industrial supplies and nearly all rural supplies. Out of a total population of slightly over 300,000 people, an estimated 189,000 people (63 percent) use ground water. There has been an increasing demand for individual ground-water supplies for homes and small industries in formerly rural areas where public water supplies are not available.

Water-yielding beds (aquifers) are present in the unconsolidated glacial drift and in the bedrock. The drift aquifers are deposits of sand and gravel that range in size from thin lenses of sand within thick sections of pebbly clay to thick beds of gravel. The bedrock formations include several aquifers. In certain parts of the area, water supplies can be obtained from comparatively shallow limestones and dolomites, and in most places water is obtainable from deep sandstones and dolomites. High mineralization of the ground water limits use of the deep aquifers in some localities.

The study reported here was made to obtain information on the geologic framework that controls the occurrence, movement, and availability of ground water in the region. Such information is necessary for solving the practical problems of obtaining adequate supplies of ground water where they are needed, both in rural areas and in areas adjacent to the cities that are becoming urban. The stratigraphy of the bedrock, which contains the most widely used aquifers, has been emphasized in the study.

Previous Investigations

Previous investigations of the ground-water geology of the area were made by Thwaites (1927), Buhle (1935), and Bergstrom (1956). Geologic reports on several quadrangles (Udden, 1912; Savage, 1922; Savage and Udden, 1922; Savage and Nebel, 1923; and Wanless, 1929, 1957) located within and near this area also contain sections on ground water.

Leverett (1899) discussed the glacial geology and the occurrence of ground water in this area, Foster (1956) described the ground-water geology of nearby Lee and Whiteside Counties, and Horberg (1950, 1956) studied the bedrock topography and glacial deposits of the area.

This report is based on data from the files of the Illinois State Geological Survey

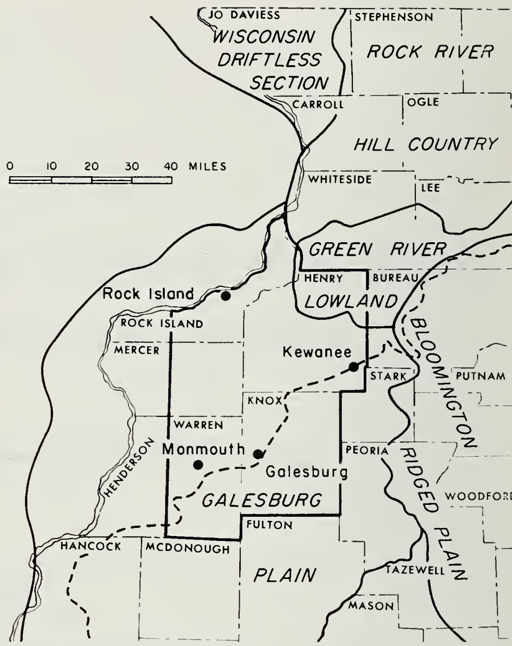


FIG. 1 — Rock Island, Monmouth, Galesburg, and Kewanee area of Illinois. The heavy outline delineates the area studied. Physiographic divisions are shown. The dashed line is the drainage divide between the Mississippi and Illinois Rivers.

and on new information collected during the investigation. Data include drillers logs, sample description logs, a few outcrop descriptions, and geophysical logs. Locations are given by county, section, township, and range.

Acknowledgments

We are pleased to acknowledge special assistance given by the members of the Geological Survey staff. Kemal Piskin prepared maps on drift thickness and drift aquifers that are the basis for those used in this report. John W. Vukovich prepared the cross section.

Appreciation also is due to the water well drillers who have supplied information and to the late W. J. Downer, Chief, Bureau of Public Water Supplies, Illinois Department of Public Health, for water pumpage data.

GEOGRAPHY

Physiography and Drainage

The Rock Island, Monmouth, Galesburg, and Kewanee area lies within two adjacent physiographic provinces of western Illinois (fig. 1), the Galesburg Plain and the Green River Lowland (Leighton, Ekblaw, and Horberg, 1948, fig. 1).

The Galesburg Plain, which includes most of the study area, is underlain by wind-blown silt (loess) and glacial pebbly clay (till). The land surface is level to undulatory and has low, glacially built ridges (end moraines). This subdued topography prevails except locally along minor streams where the relief is 50 to 75 feet and along the Mississippi and Rock Rivers where 100 to 150 feet of relief has been extensively developed. Much of the land surface configuration is controlled by the shape of the underlying bedrock surface. An end moraine separates the Galesburg Plain from the Green River Lowland.

The Green River Lowland includes all of northeastern Henry County and is a low plain with prominent sand ridges and dunes and poorly developed surface drainage. The lowland coincides in large part with the broad buried valley of the Ancient Mississippi River, which formerly flowed southeastward from north of Cordova in Rock Island County to the vicinity of Hennepin in Putnam County, then south along what is now the Illinois River Valley.

The highest elevations within the area are found between Galesburg and Kewanee where elevations of 800 to 850 feet above sea level are common. The lowest elevation is about 530 feet above sea level and occurs where the Spoon River crosses the southern boundary of Knox County. Near the Mississippi River in the northwest corner of the area, the land surface elevation is slightly less than 560 feet above sea level.

The Mississippi and Illinois Rivers are the major drainage lines of western Illinois. The divide separating their drainage basins lies partly within the area of study (fig. 1). It runs generally northeast from southwestern Warren County, passing near Galesburg, Galva, and Kewanee. The drainage patterns on either side of this divide differ. Rivers and streams on the northwest side generally follow subparallel courses from east to west, except in northern Rock Island and Henry Counties where they flow northward into the Green, Rock, and Mississippi Rivers. On the southeast side of the divide, streams and rivers are much more irregular in course and generally flow toward the south and east.

The Mississippi River Valley is only 1½ to 2 miles wide along the northern boundary of the study area, but to the west where the river follows a preglacial bedrock valley, the river valley is 7 to 8 miles wide.

Climate

The climate of the area is continental, with warm summers and cold winters (State of Illinois, 1958). Precipitation varies and a wide range of temperatures occurs during the year.

The average annual precipitation is 34 to 35 inches per year. The lowest average precipitation generally occurs in February and is about 1 inch, according to records at Moline. June and September have the largest average monthly amounts, about 4.5 and 4.1 inches, respectively. Once in 5 years the annual precipitation reaches a low of about 28 inches; the highest annual precipitation is about 38 inches.

January mean temperatures range from 22° F in northern Rock Island County to 28° F in the southern part of the area. Mean temperatures in July range from 74° to 78° F for the entire area. The average length of the growing season in most of the area is 170 to 180 days.

Population

In 1960, 300,324 people lived in the five-county area (U. S. Census Bur., 1963). The population in 1965 was estimated to be 308,400 (Ill. Tech. Advis. Comm. on Water Res., 1967, p. 23). Table 1 gives the

Table 1—Population and Water Pumpage

County	Population in 1960[a] Municipal*	Calculated non-municipal*	Total	Water pumpage (1000 gpd)[b] Municipal* (ground water)	Municipal* (surface water)	Estimated non-municipal* (ground water)	Estimated total
Henry	31,498	17,819	49,317	2,340	—	890	3,230
Knox	47,586	13,694	61,280	7,985	—	685	8,670
Mercer	8,373	8,776	17,149	565	—	438	1,003
Rock Island	122,990	28,001	150,991	852	16,556	1,400	18,808
Warren	13,415	8,172	21,587	967	—	409	1,376
Totals	223,862	76,462	300,324	12,709	16,556	3,822	33,087

[a] U. S. Bureau of the Census, 1963.
[b] Pumpage data provided by Bureau of Public Water Supplies, Illinois Department of Public Health.
* In this chart, "municipal" refers to all incorporated communities and all unincorporated communities of over 1000 that have a public water supply. "Nonmunicipal" includes rural areas and all unincorporated communities of less than 1000, with or without public water supplies.

total population of each county and the number of people in each county who are served by public water supplies derived from both surface and ground water and who live in communities of over 1,000 population (table 2, fig. 2). In the five-county area, 223,862 people live in such communities, 111,300 of whom use surface water and 112,562 of whom use ground water. If it is assumed that people who live in rural areas and in nonmunicipal unincorporated communities of less than 1,000 also rely on ground water, a total of 189,024 people use ground water.

Of the total population, 175,239 people live in Monmouth, Galesburg, Kewanee, and Rock Island and its neighboring cities of Moline and East Moline. Eighty-three percent of the population of Rock Island County is classified as urban.

Economy and Natural Resources

Diverse elements are present in the economy of this area (table 3). The value of agricultural products exceeds that of manufactures in Henry, Mercer, and Warren Counties. Rock Island County has 76 percent of the total value of manufactures and Knox County 17 percent. Rock Island County also has 50 percent of the total retail trade and 61 percent of the total shopping goods sales. The Rock Island area is a center for the manufacture of farm machinery and has the largest manufacturing arsenal in the United States.

Beef cattle and hogs are the major sources of farm income (Ross and Case, 1956). Forty percent of the crop and pasture land in 1955 was planted with corn, which is the principal cash grain crop.

The mineral resources of the area include coal, stone, clay products, common gravel, common sand, and natural bonded molding sand, whose total production in 1965 had a value of nearly 14 million dollars (Busch, 1967, p. 5-6).

About 1.4 million tons of coal, with a value of over five million dollars, was produced in 1965, nearly all of it from strip mines in southeastern Knox County. Small underground mines also are worked in Mercer and Henry Counties. The coals now being mined are the Springfield (No. 5), the Herrin (No. 6), and the Rock Island (No. 1). More than five billion tons of strippable coal (coal 18 inches or more thick and with overburden not exceeding 150 feet) reserves have been delineated with reasonable certainty in the area (Smith and Berggren, 1963, table 6).

All counties in the area produce stone, Rock Island County being one of the largest producers in the state. The stone is produced from quarries in the Silurian, Devonian, and Mississippian rocks and is used mainly for road building and agricultural limestone.

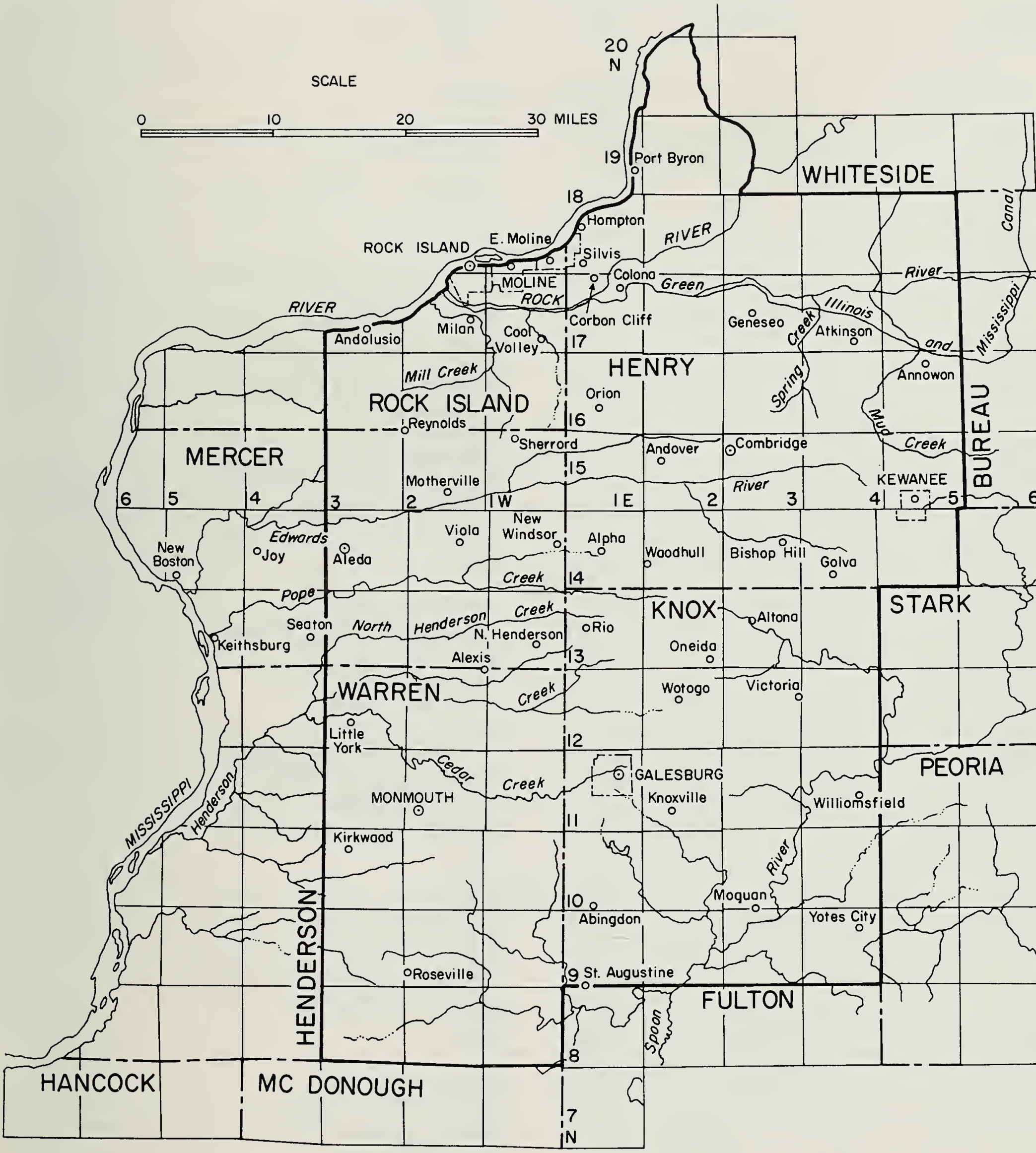


FIG. 2—Principal geographic features of the Rock Island, Monmouth, Galesburg, and Kewanee area.

GEOLOGY

Stratigraphy of the Bedrock

The bedrock of the area ranges in age from Precambrian to Pennsylvanian (fig. 3), although the only rocks exposed at the surface are of Silurian age or younger (fig. 4). The bedrock is covered by glacial deposits in most of the area. However, outcrops and well records permit a reasonably reliable interpretation of the character and distribution of the bedrock formations. The cross section in figure 5 shows the sequence and structure of the rocks in the area.

Table 2—Municipal* Water Supplies

Name	Population†	Date** begun	Apparent source of water	Pumpage‡ (1000 gpd)
		HENRY COUNTY		
Alpha	637	1900	Devonian-Silurian (Hunton), Galena-Platteville, Glenwood–St. Peter (Ancell)	45
Andover	295	1955	Devonian-Silurian (Hunton)	12
Annawan	701	1947	Devonian-Silurian (Hunton)	65
Atkinson	944	1915	Devonian-Silurian (Hunton), Galena-Platteville, Glenwood–St. Peter (Ancell)	50
Bishop Hill	164	—	Devonian-Silurian (Hunton)	8
Cambridge	1,665	1896	Devonian-Silurian (Hunton), Galena-Platteville, Glenwood–St. Peter (Ancell)	170
Colona	491	—	Devonian-Silurian (Hunton)	50
Galva	3,060	1894	Devonian-Silurian (Hunton), Galena-Platteville, Glenwood–St. Peter (Ancell)	425
Geneseo	5,169	before 1887	Drift	410
Kewanee	16,324	1883 or 1884	Galena-Platteville, Glenwood–St. Peter (Ancell), Prairie du Chien, Eminence-Potosi, Ironton-Galesville	1000
Orion	1,269	1927	Devonian-Silurian (Hunton)	75
Woodhull	779	1902	Devonian-Silurian (Hunton), Galena-Platteville, Glenwood–St. Peter (Ancell)	30
		KNOX COUNTY		
Abingdon	3,469	1902	Glenwood–St. Peter (Ancell), Prairie du Chien, Eminence-Potosi, Franconia, Ironton-Galesville	2016
Altona	505	1952	Devonian-Silurian (Hunton)	25
Galesburg	37,243	1890	Drift	5500
Knoxville	2,560	1896	Galena-Platteville, Glenwood–St. Peter (Ancell), Prairie du Chien, Eminence-Potosi, Ironton-Galesville	210
Maquon	386	1953	Devonian-Silurian (Hunton)	13
Oneida	672	1945	Devonian-Silurian (Hunton)	30
Rio	177	1958	Devonian-Silurian (Hunton)	9
St. Augustine	201	—	Keokuk-Burlington	10
Victoria	453	1950	Devonian-Silurian (Hunton)	22
Wataga	570	1955	Devonian-Silurian (Hunton)	25
Williamsfield	548	1939	Devonian-Silurian (Hunton)	60
Yates City	802	1940	Drift	65

(*Continued on next page*)

Table 2—Continued

Name	Population†	Date** begun	Apparent source of water	Pumpage‡ (1000 gpd)
		MERCER COUNTY		
Aledo	3,080	1894	Devonian-Silurian (Hunton), Glenwood–St. Peter (Ancell)	280
Joy	503	1923	Devonian-Silurian (Hunton)	40
Keithsburg	963	1893	Drift	40
Matherville	612	1952	Devonian-Silurian (Hunton)	31
New Boston	726	—	Drift	22
New Windsor	658	1924	Devonian-Silurian (Hunton)	30
North Henderson	210	1957	Devonian-Silurian (Hunton)	20
Seaton	235	1912	Devonian-Silurian (Hunton)	18
Sherrard	574	1951	Devonian-Silurian (Hunton)	30
Viola	812	1915	Galena-Platteville, Glenwood–St. Peter (Ancell)	54
		ROCK ISLAND COUNTY		
Andalusia	560	1955	Devonian-Silurian (Hunton)	45
Carbon Cliff	1268	1951	Galena-Platteville, Glenwood–St. Peter (Ancell)	34
Coal Valley	435	1902	Devonian-Silurian (Hunton)	40
East Moline	16,732	1895	Surface	3480
Hampton	742	—	Surface (from East Moline)	38
Milan	3,065	1894	Devonian-Silurian (Hunton)	330
Moline	42,705	—	Surface	5850
Port Byron	1,153	1934	Devonian-Silurian (Hunton)	58
Reynolds	494	1953	Devonian-Silurian (Hunton)	32
Rock Island	51,863	—	Surface	7226
Silvis	3,973	1910	Galena-Platteville, Glenwood–St. Peter (Ancell), Prairie du Chien, Eminence-Potosi	275
		WARREN COUNTY		
Alexis	878	1895	Devonian-Silurian (Hunton), Galena-Platteville, Glenwood–St. Peter (Ancell)	45
Kirkwood	771	1894	Keokuk-Burlington, Devonian-Silurian (Hunton), Galena-Platteville, Glenwood–St. Peter (Ancell)	37
Little York	329	1915	Devonian-Silurian (Hunton)	25
Monmouth	10,372	1886	Glenwood–St. Peter (Ancell), Prairie du Chien, Eminence-Potosi, Ironton-Galesville	800
Roseville	1,065	1895	Drift	60

* As defined in table 1.
† U. S. Bureau of the Census, 1963.
** From Hanson (1950, 1958, 1961). Where no date is given, the water supply apparently was installed subsequent to Hanson's publications.
‡ Pumpage data provided by Bureau of Public Water Supplies, Illinois Department of Public Health.

The sequence of sedimentary rocks in this area is similar to that found in several other parts of Illinois for which reports have been published (Willman and Payne, 1942; Buschbach, 1964; Bell et al., 1964). These reports provide a basis for interpreting the sedimentary rocks and the geologic history of the area.

Table 3—Economic Data for the Rock Island, Monmouth, Galesburg, and Kewanee Area*

County	Total retail trade ($1,000)	Shopping goods sales ($1,000)	Value of manufactures ($1,000)	Agriculture	
				Number of farms	Total value of products sold ($1,000)
Henry	73,358	8,145	20,384	2,702	58,851
Knox	92,421	15,102	63,679	2,034	30,190
Mercer	21,573	801	†	1,539	25,317
Rock Island	226,140	42,378	280,526	1,360	16,645
Warren	31,763	2,415	4,170	1,413	33,168
Totals	445,255	68,841	368,759	9,048	164,171

* Rand McNally and Co., 1966. Data are for 1963.
† Separate figures are not available.

The detailed information available from a deep stratigraphic test well near Rock Island (Buschbach, 1965) was used in the following lithologic descriptions. Buschbach's sample description of the E. A. South No. 1 well is given in the Appendix to this report. Those aspects of the available geologic information most relevant to ground water are emphasized.

PRECAMBRIAN ROCKS

Only one test hole in this area has penetrated Precambrian granodiorite and that, described by Buschbach (1965), had a total depth of 3,855 feet. Crystalline rocks such as the granodiorite found in the test probably underlie all of western Illinois (Bradbury and Atherton, 1965) and are well below the depths of potable ground water.

CAMBRIAN SYSTEM

Mt. Simon Sandstone

The Mt. Simon Sandstone has been penetrated by at least two water wells and two oil test wells within the area of study. In the northern part of the area, several wells for which no detailed information is available penetrate part of the Eau Claire Formation and may extend into the upper part of the Mt. Simon. It is assumed that the Mt. Simon underlies the entire region, although in a few places elsewhere in western Illinois it is locally absent, and hills of Precambrian rocks are overlain directly by the Eau Claire Formation (Bell et al., 1964).

The Mt. Simon consists of fine- to coarse-grained sandstone and some variegated shale. The sandstone is typically poorly sorted, friable, and nondolomitic. The top is commonly picked on the basis of the first occurrence of scattered, very coarse sand grains in conjunction with the presence of "sooty" grains and the absence of dolomite and glauconite.

The character of the Mt. Simon Sandstone and other deep formations is shown by the description of the core from the deep stratigraphic test well (Appendix, log 1). It is 887 feet thick just west of the study area in sec. 19, T. 13 N., R. 4 W., Mercer County, and is 1,255 feet thick near the north-central part of the area in sec. 30, T. 16 N., R. 1 E., Henry County. It is thought to thicken regularly eastward (Bell et al., 1964, fig. 7).

Eau Claire Formation

At least 13 wells or test holes, including the four holes that enter the Mt. Simon, are known or assumed to penetrate the Eau Claire Formation. The Eau Claire consists of sandstone, siltstone, shale, and some dolomite. The sandstone is silty, dolomitic, and glauconitic, and it is the predominant rock type of the Eau Claire in this area. Shale is most abundant near the middle of the formation, and the dolomite occurs near the top.

The thickness of the Eau Claire in this area is estimated to range from 225 to 300 feet. In the log of the deep stratigraphic test (Appendix, log 1) the Eau Claire Formation is 294 feet thick. Regional studies suggest that it is thickest in the southeast (Bell et al., 1964, fig. 7).

Ironton-Galesville Sandstone

The Ironton and Galesville Sandstones, differentiated in outcrop and in the subsurface in northeastern Illinois (Buschbach, 1964), are difficult to distinguish in this area. Consequently, they are treated as one unit and called the Ironton-Galesville Sandstone in this report.

The Ironton-Galesville is penetrated partially or completely by at least 24 wells or test holes within the area of study. Eleven of these partially penetrate the unit, nine penetrate fully and extend short distances into the Eau Claire, and four extend into the Mt. Simon.

The Ironton - Galesville is composed chiefly of white, fine- to medium-grained, slightly dolomitic sandstone (Emrich, 1966). Near the top, the sandstone is medium grained but contains some coarse grains, is partly glauconitic, and is commonly dolomitic. Most of the lower part of the Ironton-Galesville is fine-grained sandstone that is friable and slightly dolomitic.

The Ironton-Galesville ranges in thickness from almost 200 feet in eastern Knox County and southeastern Henry County, to an estimated 100 feet in southwestern Warren County, and to about 125 feet in northern Rock Island and Henry Counties (fig. 6). Less than 50 miles south of the area, the sandstone wedges out. In the deep stratigraphic test well (Appendix, log 1), the Ironton-Galesville is represented by 23 feet of dolomite and 106 feet of sandstone.

In figure 7, the depth to and elevation (below sea level) of the top of the Ironton-Galesville are given for most of the deep wells in the area. Data were considered insufficient for the construction of more than a very generalized structure map of the top of the formation. The most accurate estimates of depths and elevations for the Ironton-Galesville will be for locations close to datum points in figure 7. Between points, elevations can be interpolated and estimates of depth obtained by subtracting algebraically the sandstone elevation from the land surface elevation.

Alternatively, the depth to the Ironton-Galesville can be estimated by using thicknesses taken from figure 8 (thickness of the interval between Ironton-Galesville and Glenwood-St. Peter) and elevations from the Glenwood-St. Peter structure map.

Franconia Formation

The Franconia Formation is partially penetrated by three wells and fully penetrated by the 24 wells noted above that extend to deeper units. The Franconia is fine-grained, glauconitic sandstone interbedded with sandy, glauconitic dolomite and silty, glauconitic shale.

The formation thickens to the south and southwest, from 130 to 150 feet near the boundary between Henry and Bureau Counties and 120 feet in central Rock Island County to 200 feet in Mercer County and 250 feet in central Warren County.

Potosi Dolomite and Eminence Formation

The Potosi Dolomite and the Eminence Formation were formerly called the Trempealeau Dolomite and the Jordan Sandstone. Now in Illinois the name Jordan Sandstone is recognized in only the northwestern part of the state.

The Potosi Dolomite and the Eminence Formation are partially penetrated by at least 10 wells within the study area in addition to the 27 wells that extend to deeper units. The Potosi Dolomite is a fine-grained, light grayish brown, slightly glauconitic dolomite that contains drusy quartz. The overlying Eminence Formation consists of light brown to light gray, fine- to medium-grained sandy dolomite containing oolitic chert. Beds of dolomitic sandstone also are distributed throughout this unit. A well developed sandstone, the Momence Sandstone Member, is present at the base. To the north of the study area the Eminence

SYSTEM	SERIES	GROUP OR FORMATION	GRAPHIC LOG	THICKNESS (FT)	DESCRIPTION	DRILLING & CASING CONDITIONS	WATER-YIELDING PROPERTIES
QUATERNARY	PLEISTOCENE			0-230	Unconsolidated glacial deposits, loess and alluvium	Wells usually need careful development and screens	Variable; large yields from thicker sand & gravel deposits in bedrock valleys
PENNSYLVANIAN				0-400	Mainly shale with sandstone, limestone, and coal	Casing usually required	Generally unfavorable as aquifer; domestic and farm supplies obtained from thin limestone and sandstone beds locally
MISSISSIPPIAN	VALMEYERAN	Salem-Warsaw Fm		0-30	Sh, ss, and ls	Casing usually required	Not water yielding at most places
MISSISSIPPIAN	VALMEYERAN	Keokuk Ls Burlington Ls		0-170	Limestone		Generally creviced, water yielding; wells penetrate ls from 30 to more than 150 ft; dependable aquifer for farm supplies in much of area
MISSISSIPPIAN	KINDERHOOKIAN	Chouteau		0-275	Shale	Casing required	Not water yielding at most places; limestones within shale are source of small farm supplies locally
MISSISSIPPIAN	KINDERHOOKIAN	New Albany Group					
DEVONIAN	UPPER	New Albany Group					
DEVONIAN	MIDDLE	Hunton Megagroup		20-375 / 20-140	Limestone		Devonian limestone locally water yielding from crevices; Silurian dolomite more dependable aquifer for farm supplies in most areas; satisfactory wells may require penetration from 25-150 ft into Silurian; dolomite usually "tighter" in lower half
SILURIAN	NIAGARAN	Hunton Megagroup		20-375 / 0-375	Dolomite, cherty at base		
SILURIAN	ALEXANDRIAN	Hunton Megagroup					
ORDOVICIAN	CINCINNATIAN	Maquoketa Group		200-215	Green to blue and brown shale with limestone and dolomite	Shale requires casing	Generally not water yielding
ORDOVICIAN	CHAMPLAINIAN	Ottawa Mg — Galena and Platteville Groups		300-320	Dolomite with shaly zone near middle; limestone in lower part	Crevicing not common	Not important as aquifer; crevices yield some water
ORDOVICIAN	CHAMPLAINIAN	Ancell Gr (Glenwood-St. Peter Ss)		70-250	Sandstone; green shale; cherty shale at base	Shale may require casing; sand may cave	Dependable source of ground water

FIG. 3—Geologic formations of the Rock Island, Monmouth,

SYSTEM	SERIES	GROUP OR FORMATION		GRAPHIC LOG	THICKNESS (FT)	DESCRIPTION	DRILLING & CASING CONDITIONS	WATER-YIELDING PROPERTIES
ORDOVICIAN	CANADIAN	Prairie du Chien Group	Shakopee		80-275	Dolomite with some shale and sandstone	Casing not required; crevices encountered locally	Some water from sandstones and creviced dolomite; not developed for large supplies
			New Richmond Ss		40-90	Sandstone with some dolomite		
			Oneota Dol		200-300	Dolomite, cherty		
CAMBRIAN	CROIXAN	Eminence Fm			50-120	Dolomitic sandstone and sandy dolomite		
		Potosi Dol			150-200	Dolomite with drusy quartz		
		Franconia Fm			120-200	Green sandstone, shale, and dolomite		
		Ironton-Galesville Ss			100-200	Sandstone, partly dolomitic	May cave	Widespread and important aquifer for large supplies
		Eau Claire Fm			225-300	Sandstone and shale with some dolomite	Weak shales may require casing	Some water from sandstone
		Mt. Simon Ss			800-1300	Sandstone, beds of shale and siltstone	Casing not required	Water yielding
PRECAMBRIAN						Igneous rock		Not water yielding

Galesburg, and Kewanee area and their water-yielding properties.

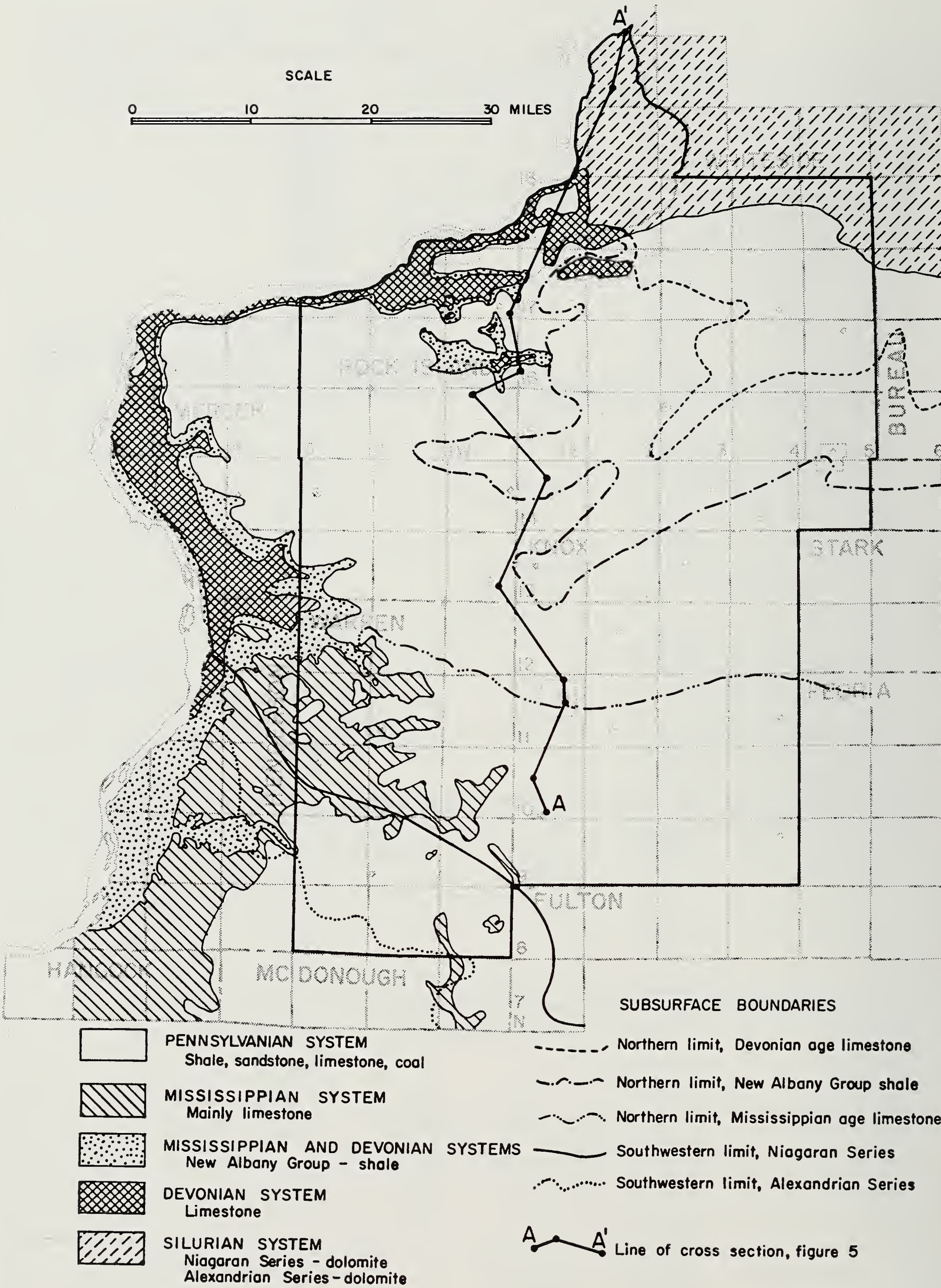


FIG. 4—Bedrock geologic map with selected subsurface geologic boundaries.

thins slightly and becomes increasingly sandy, grading into the Jordan Sandstone.

A description of the Eminence and Potosi Formations in this area is included in the record of the deep stratigraphic test in Henry County (Appendix, log 1). In that well the Potosi is 166 feet thick and the Eminence 61 feet thick. In southeastern Henry County, sec. 4, T. 14 N., R. 5 E., the Potosi is 190 feet thick and the Eminence 115 feet thick.

ORDOVICIAN SYSTEM

Prairie du Chien Group

The Prairie du Chien Group in the study area is partially penetrated by at least 20 wells and is completely penetrated by the 37 wells and test holes that reach deeper units. The formations composing this group consist of partly cherty, partly sandy dolomite, with some sandstone interbedded. The group underlies all of this area, and is divided into three formations, the Oneota Dolomite, the New Richmond Sandstone, and the Shakopee Dolomite, in ascending order. East and south of the area of study, an additional formation, the Gunter Sandstone, occurs below the Oneota. The Shakopee Dolomite was partly eroded before deposition of the overlying Ancell Group began. The thickness of the Prairie du Chien, therefore, is irregular.

The Oneota Dolomite is generally light gray, medium grained and cherty. Thicknesses of about 225 to 250 feet have been reported in Rock Island County. In Knox County it is 275 to 300 feet thick.

The New Richmond Sandstone consists of dolomitic, fine- to medium-grained sandstone and sandy, fine-grained dolomite. The formation is 45 to 50 feet thick in the Rock Island vicinity, thickens from 75 to 90 feet in Henry and Knox Counties, and reaches 175 feet in north-central Illinois. In Warren and McDonough Counties it appears to thin markedly but perhaps irregularly. It terminates a short distance to the south of the study area.

The Shakopee Dolomite is a very fine-grained, gray or reddish gray dolomite containing some chert. It has been thinned by pre-St. Peter erosion and ranges in thickness from 83 to 275 feet. Most of the thinning is in the northeastern part of the area.

The sample study of the City of Kewanee No. 4 well (Appendix, log 2) shows the characteristics of the Prairie du Chien Group.

Ancell Group

The Ancell Group, which in the study area consists of the Glenwood Formation and the St. Peter Sandstone, underlies the entire area, where it is penetrated by at least 87 wells and test holes. Thirty of these partially penetrate the Ancell, 18 penetrate the full thickness but extend only a few feet into the Shakopee, and 39 extend to the New Richmond or deeper units.

The Ancell Group consists of four rock units in much of this area. These units are most easily differentiated in south-central Rock Island County where they have been penetrated by several structure tests in which geophysical logs were run.

The basal unit of the Ancell Group is characterized by a predominantly green shale containing chert and some sandstone. This is the Kress Member of the St. Peter Sandstone. The Kress is usually thin (2 to 10 feet) but in some places reaches thicknesses of 30 to 40 feet. It is irregular in distribution and is thought to be the initial deposit of the Ancell Group.

A white, fine-grained sandstone, the Tonti Member of the St. Peter Sandstone, overlies the Kress Member. It is present in the entire study area and is irregular in thickness, ranging from 60 to about 100 feet.

Above the white Tonti Sandstone is a complex unit that is largely of green, sandy shale and is called the Kingdom Member of the St. Peter Sandstone. It underlies all of the area of study except southeastern Knox County, being thickest in south-central Rock Island County where it reaches a maximum of almost 25 feet; it thins to the south and east. In the areas of thinning it may be discontinuous. In well cuttings, if the green shale is absent it may be difficult

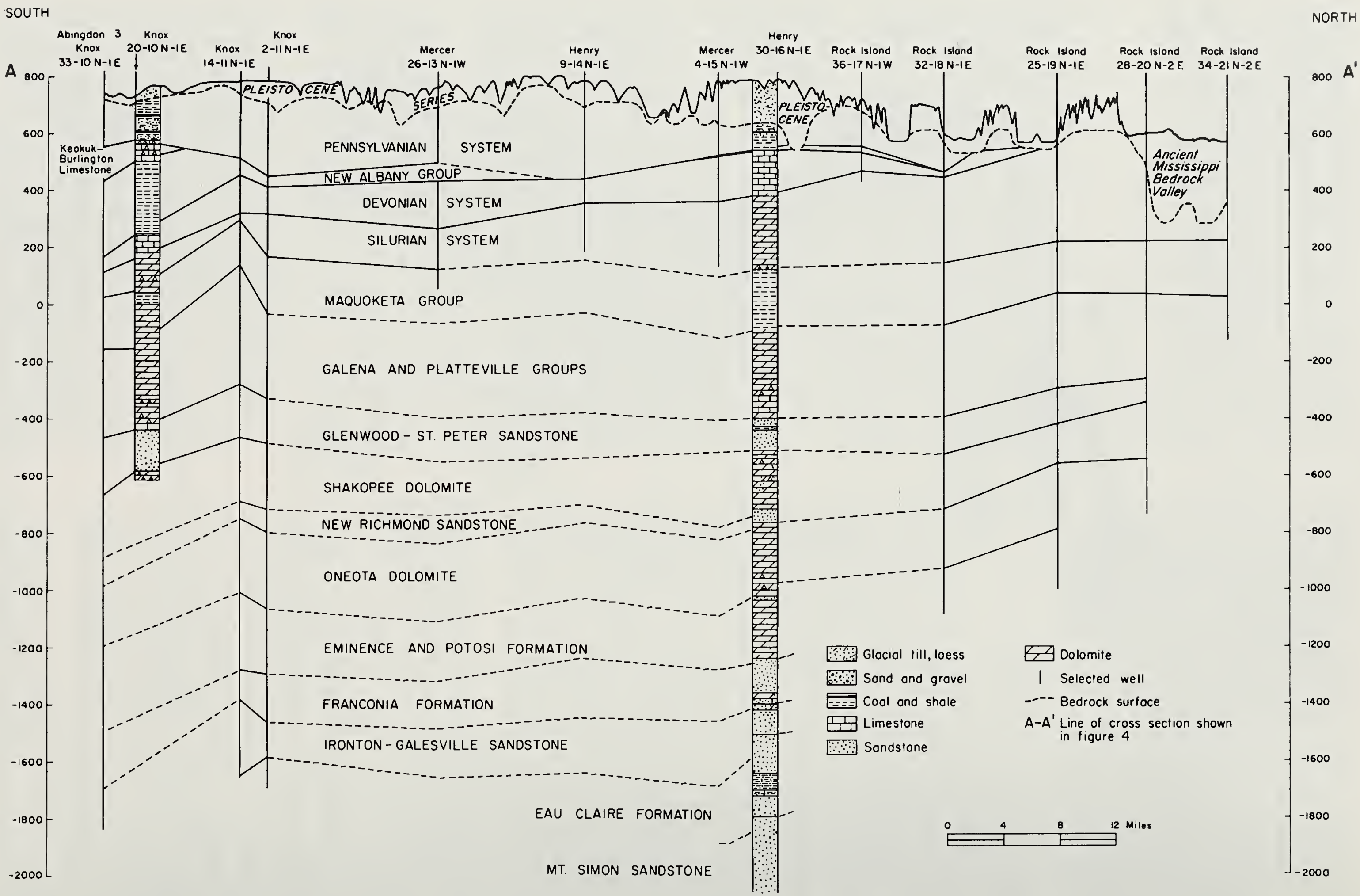
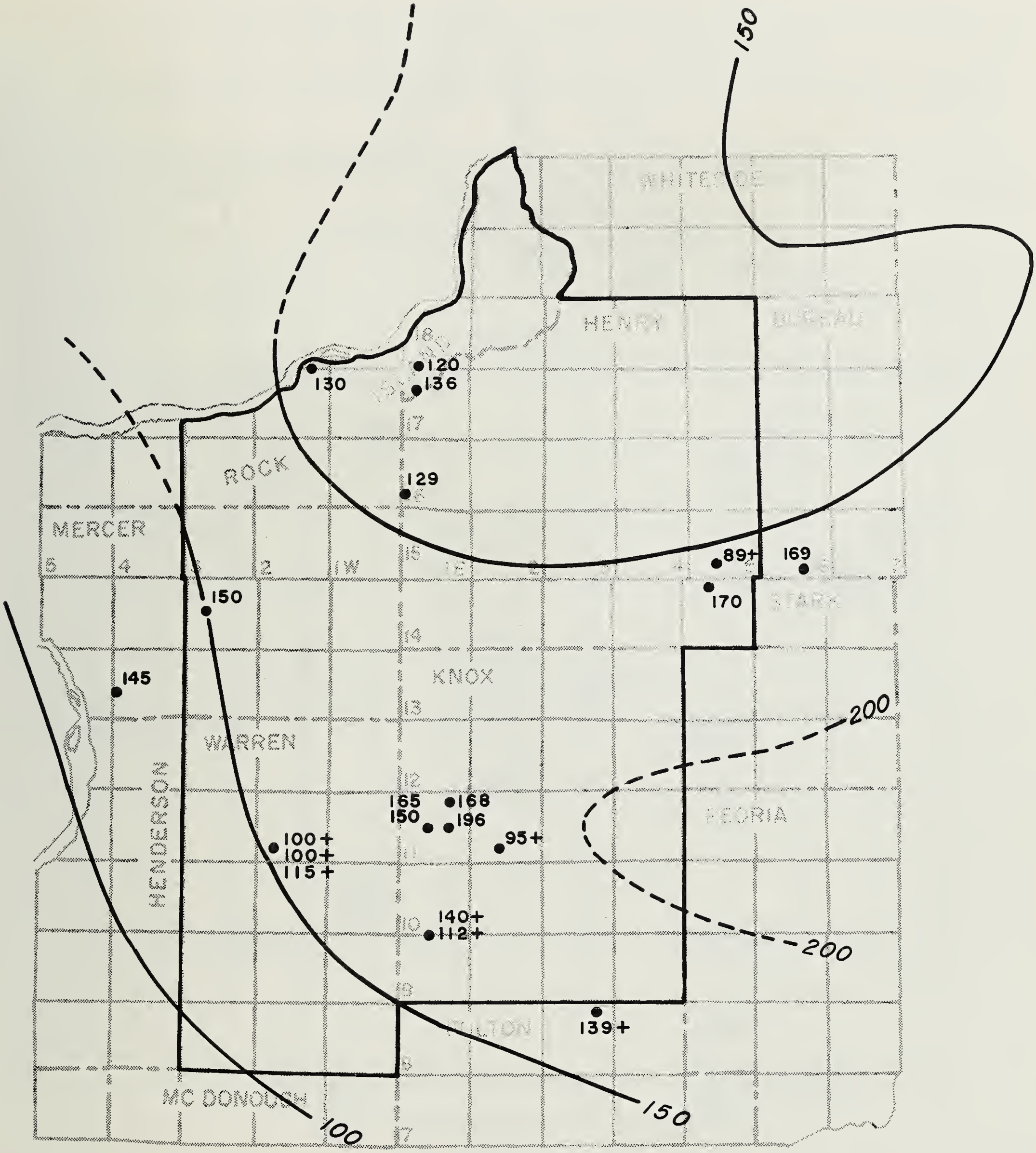


FIG. 5—Cross section of formations, bedrock surface, and land surface from Abingdon, Knox County, to northern Rock Island County.



--- 150 Thickness, interval 50 feet

• 169 Datum point. May represent more than one well. Numbers give logged thickness in feet.

SCALE

0 10 20 30 MILES

FIG. 6—Thickness of the Ironton-Galesville Sandstone. (Modified from Emrich, 1966.)

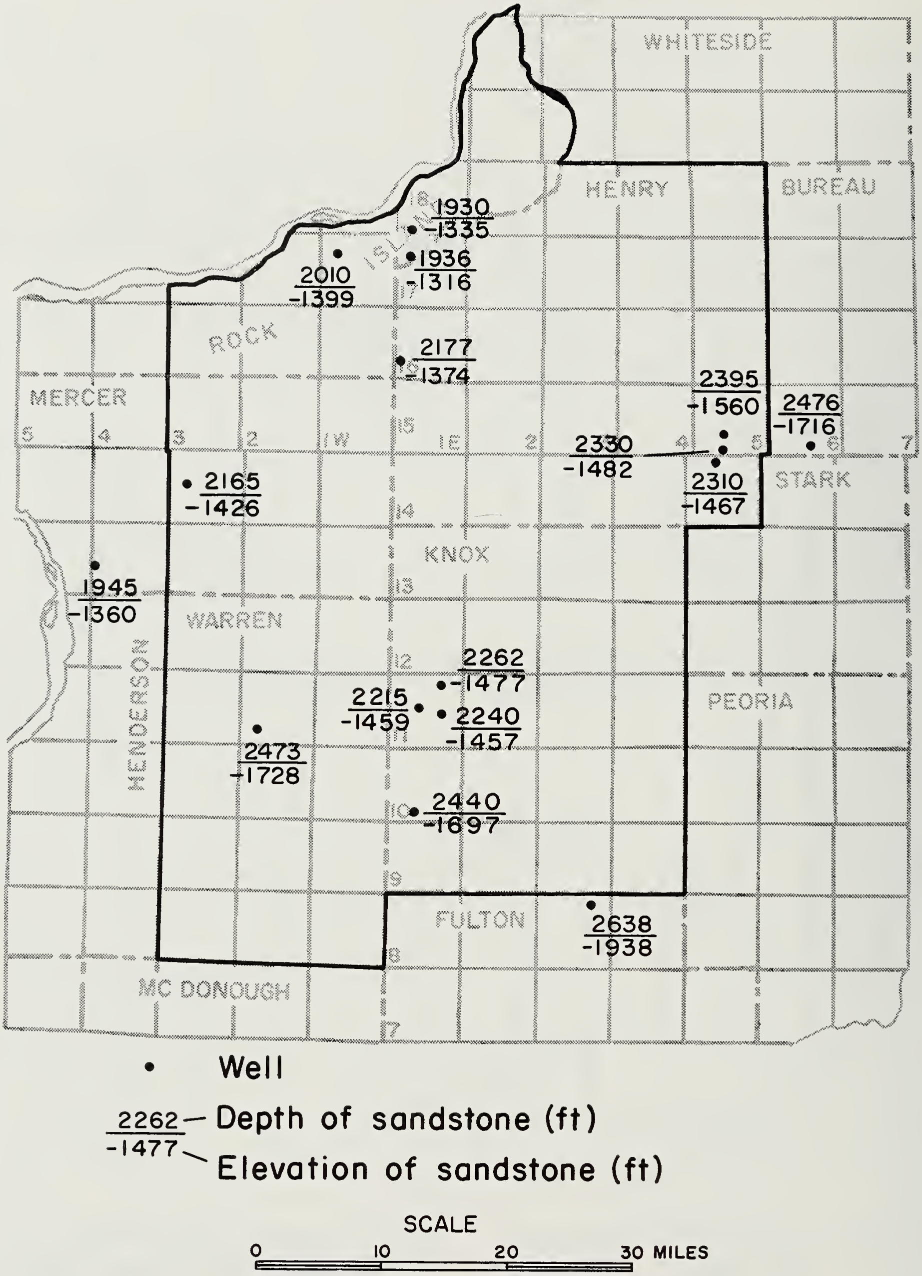


FIG. 7—Depth and elevation of the top of the Ironton-Galesville Sandstone.

to distinguish the Tonti Sandstone Member from the uppermost sand unit, the Starved Rock Member of the St. Peter, and from the Glenwood Formation.

The upper sand unit is a white, fine- to medium-grained, friable sandstone that in the Rock Island area contains at least two beds of green shale that may be of limited areal extent. This sandstone is 60 to 70 feet thick in the southern part of the area and thins northward. It is absent north of a boundary that approximates the position of

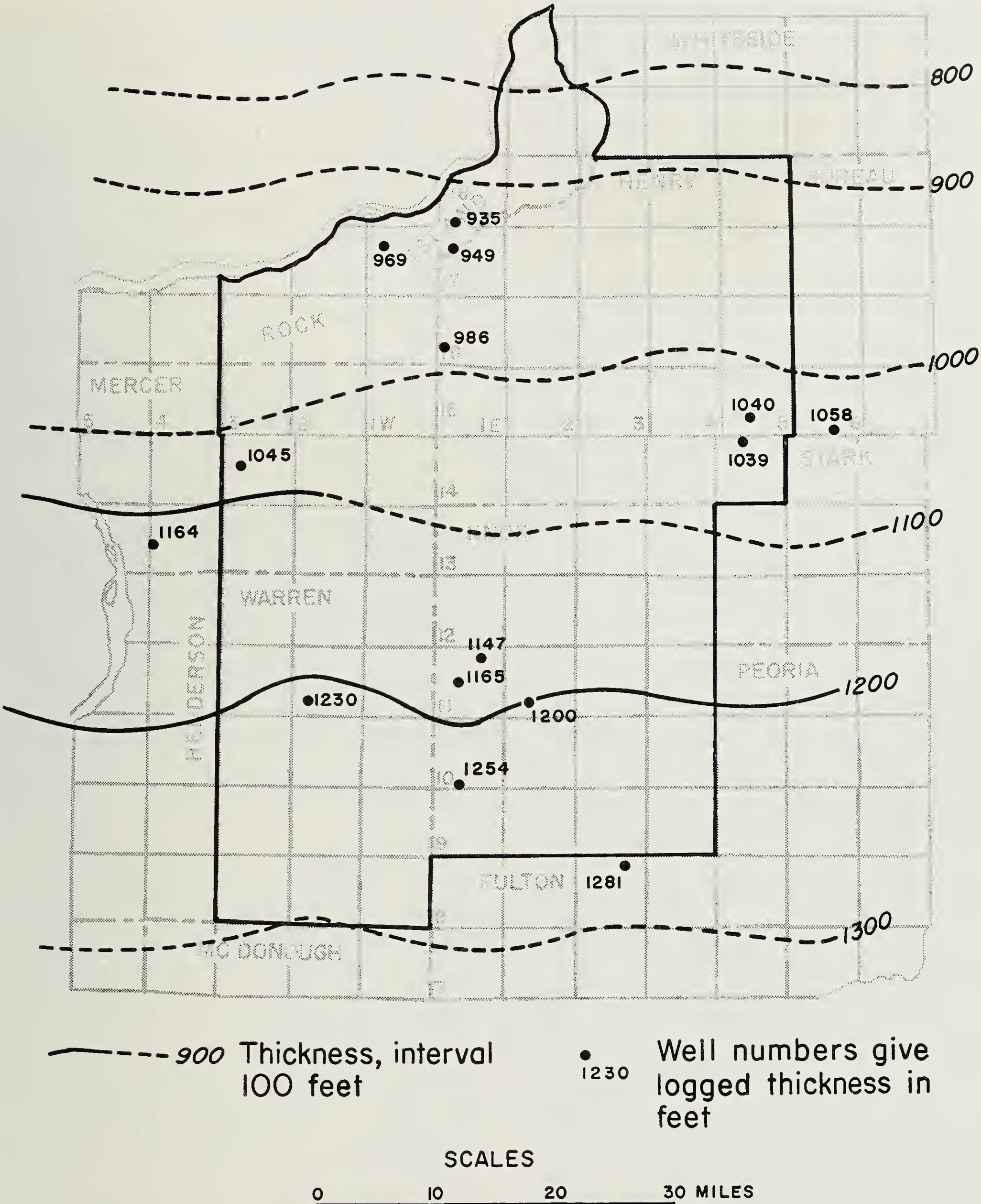


FIG. 8—Thickness of the interval between the top of the Glenwood-St. Peter Sandstone (Ancell Group) and the top of the Ironton-Galesville Sandstone.

the Mississippi River at the Tri-Cities. It may extend a short distance farther north in eastern Rock Island County.

The four units of the Ancell Group are differentiated in the description of core from the deep stratigraphic test well (Appendix, log 1). The thickness of the Ancell Group is irregular and no attempt was made to draw thickness contours for it. Instead, reported thicknesses for the group are shown in figure 9. Since the Ancell Group is the deepest sandstone aquifer for which a moderate amount of data is available, a structure map of its top was made (fig. 10).

Platteville and Galena Groups

Within the area of study, 23 wells and test holes of record terminate in the Platteville and Galena Groups (Ottawa Megagroup). The Platteville Group consists of gray or brown, very fine-grained dolomite and limestone. The overlying Galena Group is chiefly medium-grained, buff-colored dolomite with reddish brown shale partings

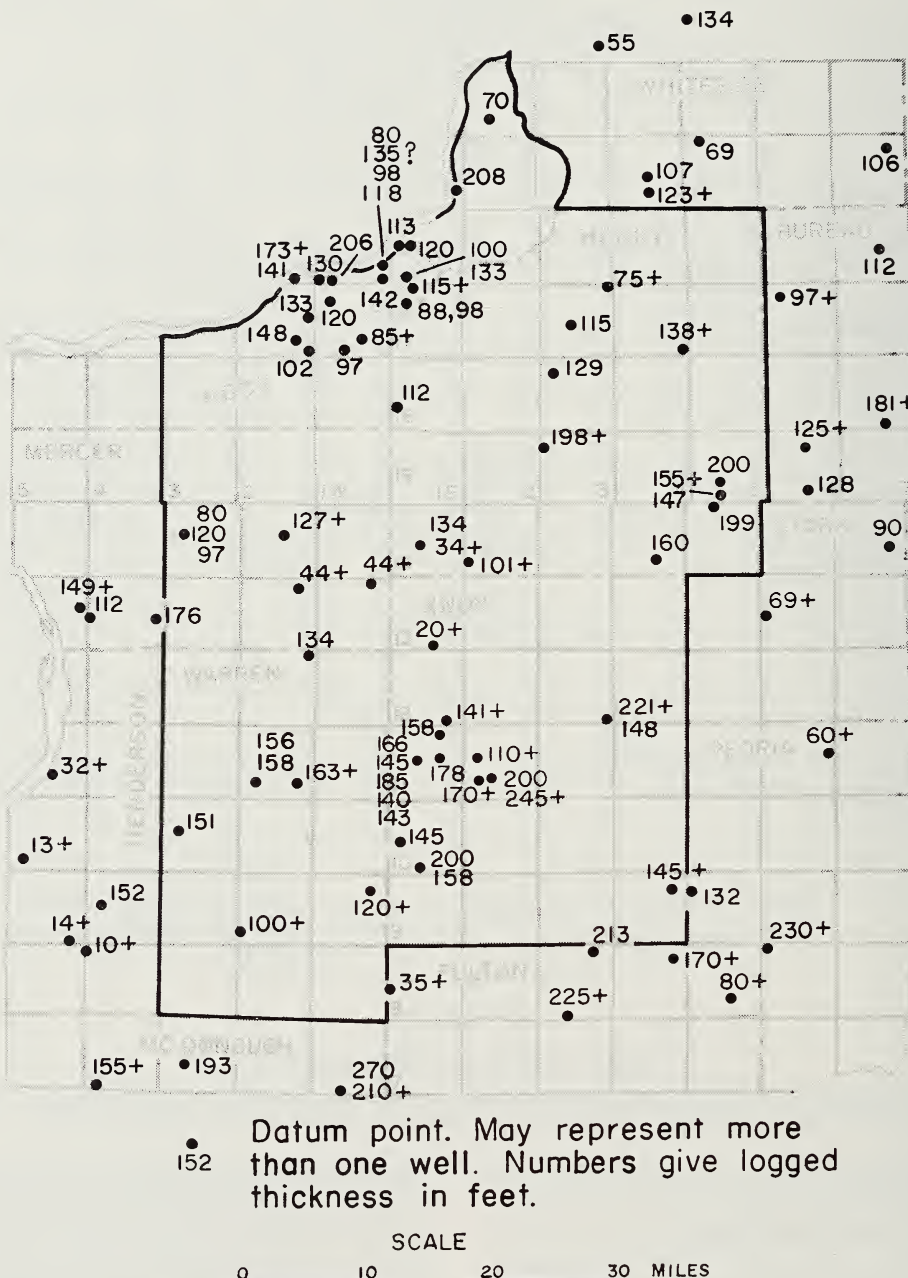


FIG. 9—Thickness of the Glenwood–St. Peter Sandstone (Ancell Group).

at the base. The combined thickness of the two groups averages between 300 and 320 feet in the area.

Maquoketa Group

The Maquoketa Group consists of two units of dolomitic and silty shales that are separated by a silty dolomite. The group averages between 200 and 215 feet thick in most of the area, but in southwestern Warren County it has been thinned by pre-Middle Devonian erosion.

SILURIAN AND DEVONIAN SYSTEMS

Hunton Megagroup

The Hunton Megagroup includes carbonate rocks of Silurian and Devonian age. Its occurrence to the south in the subsurface was described by Whiting and Stevenson (1965).

Hundreds of wells within the study area penetrate part or all of the Hunton. Of the records on file at the Illinois Geological Survey 185 were selected for this study. Records for wells to deeper horizons were also used.

The Silurian strata are assigned to the Alexandrian and Niagaran Series. Alexandrian rocks include yellowish gray, partly cherty dolomite overlying gray, argillaceous, dolomitic siltstone. The Niagaran rocks are light gray dolomite. The Silurian strata have been removed by erosion from southern Henderson County, extreme southwestern Warren County, and most of central and western McDonough County. The area from which Silurian rocks have been eroded is delineated by the line showing the southwestern limit of the Alexandrian Series (fig. 4); the Niagaran Series is present a few miles northeast of this line. Silurian rocks thicken in a northeasterly direction to a maximum of almost 400 feet. Irregularities in the thickness of the Silurian are attributable to pre-Middle Devonian and later erosion.

Devonian strata underlie all of the report area except northeastern Rock Island County where Silurian rocks are at the bedrock surface or lie directly below the Pennsylvanian (fig. 4). The lower unit of the Devonian is the Wapsipinicon Formation, a brownish gray, sublithographic limestone. It is present in Rock Island, Mercer, Henry, and northern Warren and Knox Counties. In the rest of the area, it is generally 20 to 40 feet thick. The overlying unit, the Cedar Valley Formation, is gray to brown limestone and some dolomite that is very fine grained and fossiliferous. It underlies all of the area except northeastern Rock Island and Henry Counties. Its thickness ranges from 20 feet to over 100 feet.

The characteristics of the Hunton Megagroup are given in the partial sample study log of the Village of North Henderson No. 1 well (Appendix, log 3).

The thickness of the Hunton Megagroup ranges from less than 100 feet in the southwestern part of the area where the Devonian rocks predominate to approximately 400 feet in the northeastern part of the area where the Silurian (especially the Niagaran) rocks predominate (fig. 11). North of the northern limit of the New Albany Group (Lower Mississippian-Upper Devonian) (fig. 4), the Hunton Megagroup has been beveled by pre-Pennsylvanian erosion.

DEVONIAN AND MISSISSIPPIAN SYSTEMS

Upper Devonian and Lower Mississippian shale (Collinson, 1961) of the New Albany Group underlies all of the area except a band that varies in width across the northern part where the shale has been removed by pre-Pennsylvanian erosion (fig. 4). The northern boundary of the shale is shown in figure 4 but is probably much more complex than is indicated. Between the eroded northern edge of the shale and the northern limit of overlying Keokuk-Burlington Limestone (fig. 4), the shale has been beveled by erosion. The New Albany Shale that is of Mississippian age probably is present only in the southern part of the area of study. The New Albany has a maximum thickness of about 275 feet near the northern limit of the Keokuk-Burlington; it

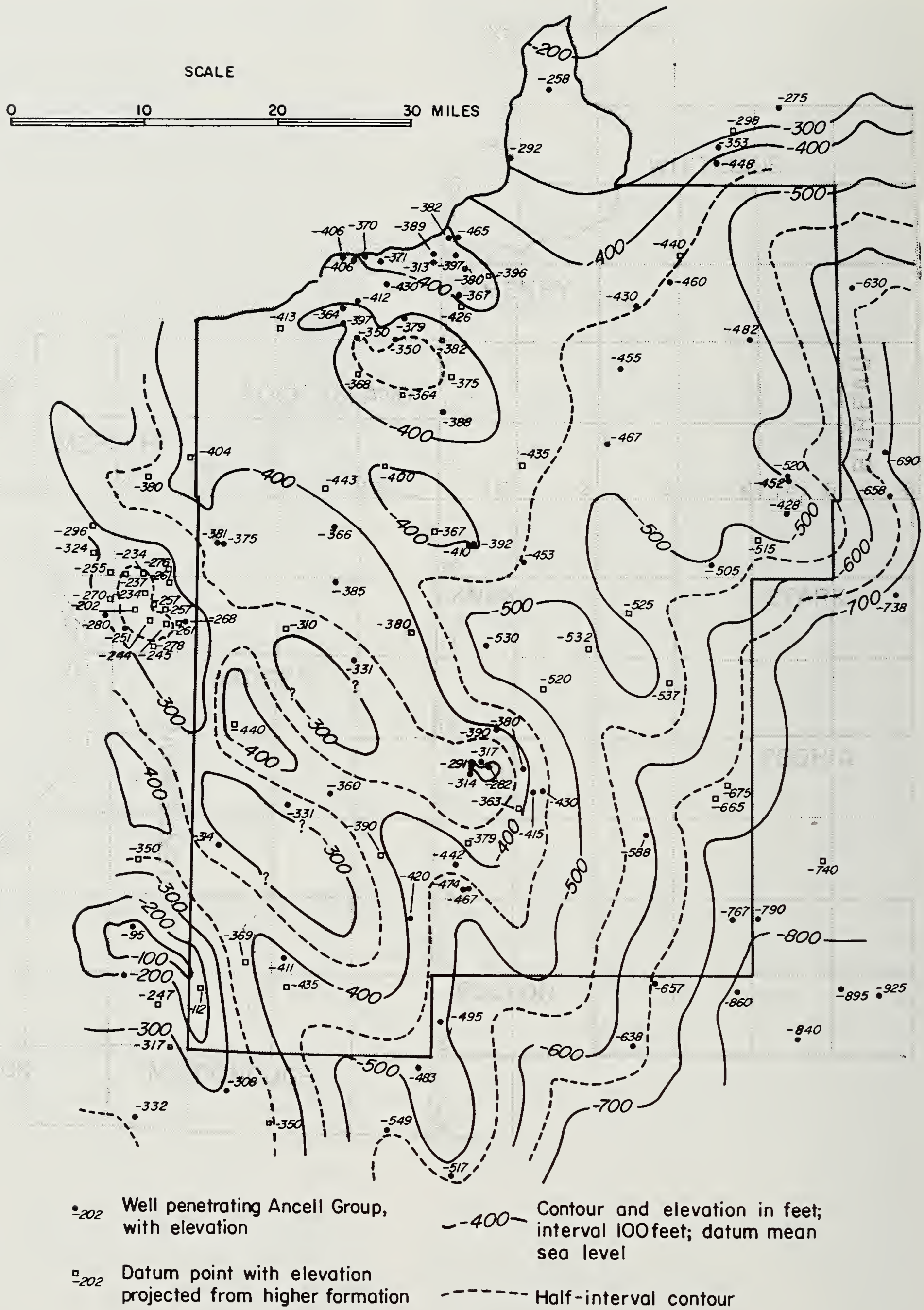


FIG. 10—Elevation of the top of the Glenwood–St. Peter Sandstone of the Ancell Group. Estimated thicknesses were projected downward from the tops of the Maquoketa and Galena Groups to supplement elevations of the top of the Ancell Group.

thins toward the south (Workman and Gillette, 1956, figs. 3 and 6). Included in the New Albany are a thin gray shale at the base, a dark brownish black, silty, *Tasmanites*-bearing shale, and a greenish to bluish gray shale.

Above the New Albany Group lies the Keokuk-Burlington Limestone of Valmeyeran age. Records for 33 wells that penetrate all or part of the Keokuk-Burlington were selected for this study, all of them in Knox and Warren Counties. Several of the wells also penetrate the Hunton Megagroup.

The character of the Keokuk-Burlington and of the underlying shale is shown by the sample study log of a well in Knox County (Appendix, log 4).

Above the Keokuk-Burlington is the Warsaw Shale, which is predominantly shale but includes some limestone, and the Salem Limestone, which is generally light brown, fossiliferous, and dolomitic and includes some sandstone and siltstone. The Warsaw and Salem are present in west-central Warren County and in McDonough and Fulton Counties (Harvey, 1964). They have been beveled by pre-Pennsylvanian erosion.

PENNSYLVANIAN SYSTEM

Rocks of Pennsylvanian age were deposited on the uneven surface of the underlying Mississippian and older rocks. Pennsylvanian rocks underlie all of the study area (fig. 4), except where they have been removed by preglacial erosion. The rocks are primarily shale but include various amounts of sandstone, underclay, coal, and limestone (Appendix, log 5). The sandstones sometimes are found in channels, where they are relatively thick. The lower Pennsylvanian sandstones are conglomeratic in some places, although more commonly they are fine grained and silty.

Structure of the Bedrock

The bedrock formations of the study area, in general, dip gently southeast toward the center of the Illinois Basin. At various times during the deposition of the bedrock units, earth movements of both local and regional extent disturbed the structural attitude of the sedimentary rocks.

For the purposes of this study, the most important horizon for structural mapping is the top of the Glenwood-St. Peter Sandstone, the Ancell Group (fig. 10), which is also the base of the Platteville Group. This horizon is the top of a major sandstone aquifer, whose structure is probably similar to that of deeper sandstone units, including the Ironton-Galesville. Structure of the Glenwood-St. Peter top is also essentially parallel to the top of the Galena Group and, in most of the area, to the top of the Maquoketa Group. In the construction of the structure map (fig. 10), estimated thicknesses were projected downward from the tops of the Maquoketa and the Galena to supplement elevations of the top of the Ancell Group. The structure map of the top of the Galena Group presented by Whiting and Stevenson (1965, fig. 7) was followed in part in the contouring of figure 10, especially for the northwest-southeast "grain" of the structure.

Relatively intensive folding of the sedimentary rocks is found between northern McDonough and Fulton Counties on the south and south-central Rock Island County and southwestern Henry County on the north (fig. 10). Small, randomly oriented structures are present to the southwest of this area of folding (Whiting and Stevenson, 1965, fig. 7) and, to a lesser degree, to the northeast of it. In the folded area, essentially parallel anticlines and synclines predominate.

Three small anticlinal domes have been defined by drilling within and near the area of study. They are located in south-central Rock Island County (Buschbach, 1965), southwest Mercer County, and southeast Henderson County. Similar structures may well be present elsewhere in the vicinity. For example, in central and northern Warren County, and also in eastern Mercer County and southwestern Henry County, the data suggest the possibility of closed contours.

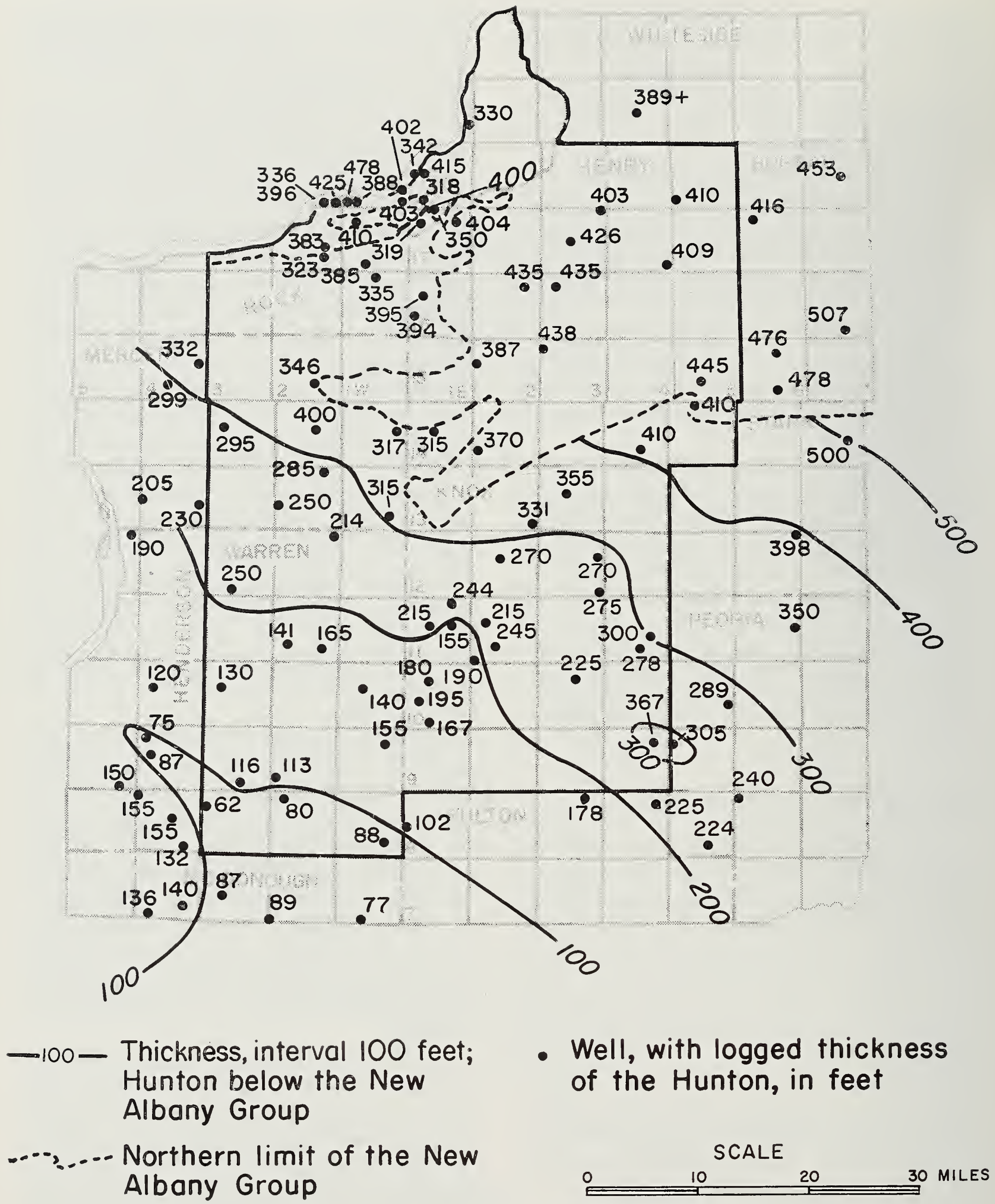


FIG. 11—Thickness of the Silurian-Devonian limestone and dolomite of the Hunton Megagroup. Devonian rocks predominate in the southwestern part of the area and Silurian rocks in the northeastern part. North of the northern limit of the New Albany, the Hunton Megagroup has been beveled by pre-Pennsylvanian erosion.

No major faulting has been recognized in the area, but several major intervals of structural activity can be inferred from the rocks of this area. A structural uplift that took place at the end of Ordovician Prairie du Chien time led to erosion of the Shakopee Dolomite to thicknesses of less than 100 feet in several places in the northeastern part of the area.

A broad uplift called the Sangamon Arch (Whiting and Stevenson, 1965) probably began in late Silurian time and persisted until after Middle Devonian time. The erosion that followed the formation of Silurian rocks removed several hundred feet of strata before Devonian deposition. All Silurian strata have been removed from extreme southwestern Warren County, from the southern half of Henderson County, and from the area farther to the southwest where Middle Devonian rocks rest on the eroded surface of the Ordovician Maquoketa Group (fig. 4). In most of the study area, however, partially eroded Silurian dolomite underlies Middle Devonian strata.

At the end of Mississippian time, a major structural disturbance resulted in the formation of the LaSalle Anticline (Willman and Payne, 1942). In the study area, a sharp unconformity at the base of the Pennsylvanian gives proof of the disturbance. The unconformity truncates the Silurian in northern Rock Island County and, toward the south into southern Warren County, progressively younger rocks, including the Middle Devonian, the Upper Devonian and Lower Mississippian rocks, and the Middle Mississippian rocks.

Glacial Geology and Bedrock Topography

Four major stages of glaciation of the Pleistocene Series (fig. 3) are represented by the unconsolidated deposits found above the bedrock within and near the area of study. The bedrock surface upon which the deposits were laid had a complex erosional history (Horberg, 1946, 1950). It is characterized by broad uplands that have been incised by deep valleys. Between epochs of glaciation, normal weathering and erosion took place. Outcrops are common along streams in areas where the drift is thin.

The oldest glacier, the Nebraskan, probably entered the western part of the state and covered much of the study area. Deposits of till, sand, and gravel attributed to this glacier are found a short distance to the southeast of the study area (Wanless, 1957, p. 128). Deposits in northwestern Warren County and southwestern Mercer County have been identified as Nebraskan (Horberg, 1956), but may be Kansan in part (Frye, Willman, and Black, 1965).

A lobe of ice of Kansan age from a northwestern source covered this area and deposited at least 78 feet of till, sand, and silt (Horberg, 1956, Pleistocene section 6). The following description of an exposure south of Rock Island shows a sequence of materials that is thought to be characteristic of much of the area (adapted from Horberg, 1956, Pleistocene section 1).

	Thickness (*ft*)	Depth (*ft*)
PLEISTOCENE SERIES		
WISCONSINAN STAGE		
Peoria Loess, yellowish brown, noncalcareous ..	10	10
ILLINOIAN STAGE		
Truncated Sangamonian weathering profile		
Till, yellowish brown, clayey, noncalcareous ..	2	12
Till, as above, gravel at base	7	19
Loveland (?) clay	1	20
KANSAN STAGE		
Truncated Yarmouthian weathering profile		
Till, dark, sandy, hard, calcareous	12	32
Till, dark, calcareous.....	13	45
Till, dark gray, calcareous	14	59
Sand, silty, calcareous ...	12	71
Sand, gravelly, calcareous	5	76
Till, sandy, calcareous ...	4	80
Early Kansan		
Silt and sand	3	83
Silt	2	85

The Illinoian glacier covered most of Illinois, including the area of study. Illinoian deposits (see section described above) are usually less than 50 feet thick and are generally fine textured.

The Buffalo Hart Moraine, which defines one of the three substages of the Illinoian Stage, lies (fig. 12) just west of London Mills in Fulton County and runs generally northeast past Maquon to a point just west of Williamsfield in Knox County, then northwest past Oneida, and from there north-northeast to a point in central Henry County where it passes below younger deposits.

Deposits of the Wisconsinan Stage consist of tills and associated ice-contact deposits in northeastern Henry County. The Shelbyville Moraine, which marks the western limit of Wisconsinan glaciation (fig. 12), enters Henry County just north of Kewanee and goes west for several miles before turning northwest and running past Geneseo into extreme northeastern Rock Island County. Loess of Wisconsinan age covers the entire area and is more than 25 feet thick in some places along the Mississippi River. Wisconsinan outwash, sand dunes, and lake beds are found along the major drainage lines, including the Mississippi, Rock, and Green Rivers.

The physical properties of the glacial drift materials, particularly as they relate to their potential for water supply, and the thickness of the drift are quite varied. In large areas, the drift is less than 50 feet thick, but in a few places it may be more than 200 feet thick (fig. 13). It consists largely of till, as shown in the following record from Warren County.

Monmouth School District No. 222, sec. 26, T. 11 N., R. 2 W., Warren County, Illinois. Total depth 1273 feet. Elevation 745 feet. Illinois Geological Survey sample set 28812. Drilled by K. Schmeiser. Studied by G. H. Emrich, July 1957.

	Thickness (*ft*)	Depth (*ft*)
PLEISTOCENE SERIES		
No samples	20	20
Till, silty, brown to light brown, leached	5	25
Till, very silty, yellowish gray to gray, leached	5	30
Till, silty, yellowish buff, oxidized, calcareous, slightly sandy	20	50

Areas of thick drift are relatively small (fig. 13). At three places within the area of study the drift thickness is known to exceed 200 feet (fig. 13). In two of these (extreme northwest Warren County and northeast Henry County) the drift is associated with buried portions of the Ancient Mississippi River Valley, and in the third (south-central Rock Island County) there is a broad ridge on the land surface and a valley on the bedrock surface. Some areas of thick drift appear to be barren of permeable materials, as is illustrated by the following record from Henry County.

Elizabeth Edwards well, sec. 11, T. 16 N., R. 1 E., Henry County, Illinois. Total depth 357 feet. Elevation 709 feet. Illinois Geological Survey sample set 15148. Drilled by Larson and Swanson. Studied by M. V. Strantz, 1946.

	Thickness (*ft*)	Depth (*ft*)
PLEISTOCENE SERIES		
Soil, noncalcareous, brown	4	4
Silt, slightly calcareous, dark yellowish orange	26	30
Till, calcareous, moderate yellowish brown	17	47
Till, calcareous, dark yellowish brown	8	55
Till, calcareous, moderate yellowish brown	10	65
Till, calcareous, dark yellowish brown	23	88
Till, calcareous, dark yellowish brown to gray	12	100
Till, calcareous, grayish brown	50	150
Till, calcareous, dark yellowish brown	7	157

The deposits that occur at shallow depths along major glacial drainage lines commonly consist of interbedded coarse- and fine-textured materials. These deposits, although of varied texture, are generally very permeable and areally extensive. The following record shows the nature of the materials.

Henry Martens No. 6 well, sec. 29, T. 18 N., R. 4 E., Henry County, Illinois. Total depth 42 feet. Elevation 612 feet. Illinois Geological Survey sample set 51536. Drilled by Gibbs Well Drilling Company. Drillers log, April 1965.

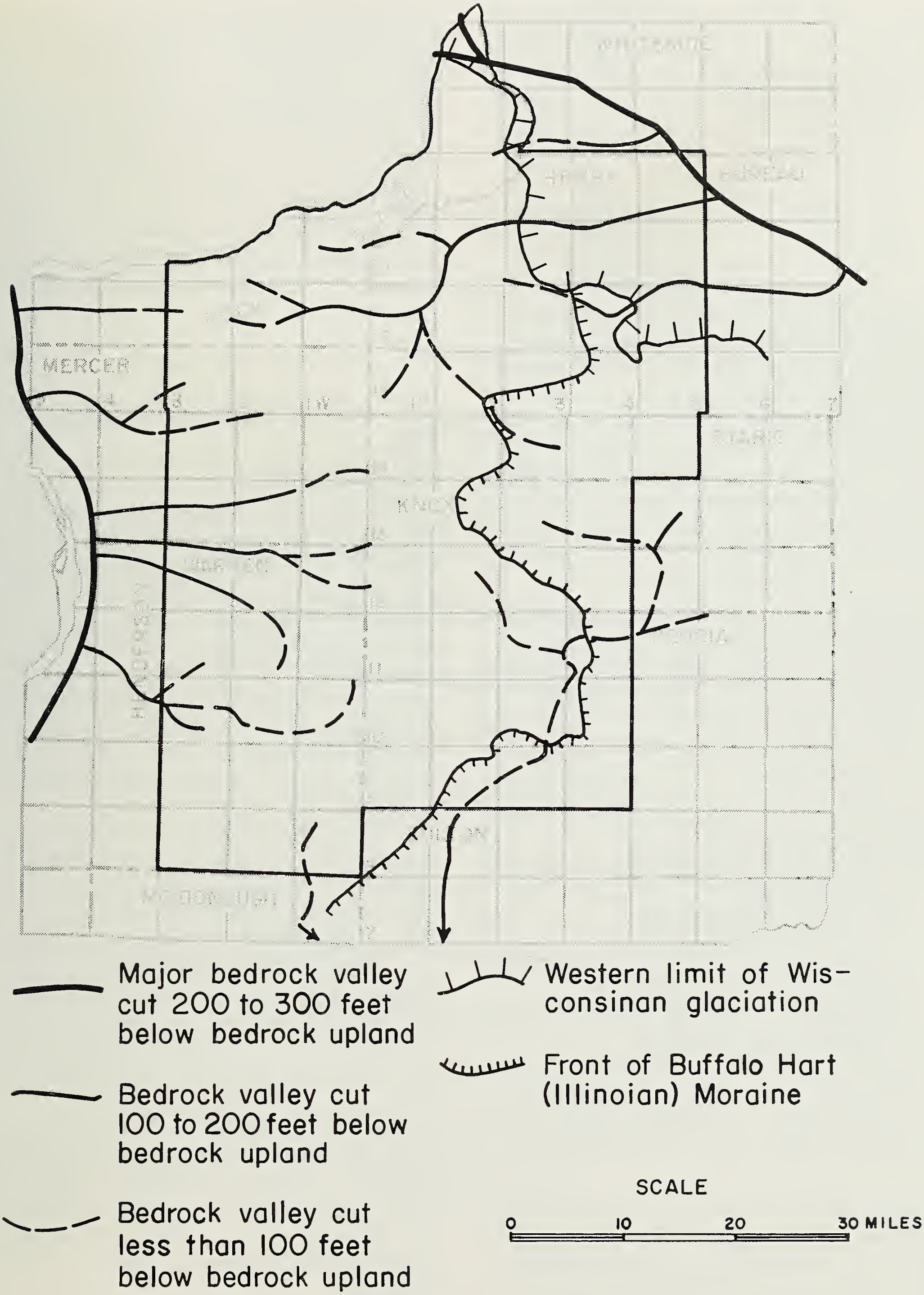


FIG. 12—Bedrock valleys (after Horberg, 1950) and major drift boundaries.

PLEISTOCENE SERIES	Thick-ness (*ft*)	Depth (*ft*)
Black sandy topsoil	1	1
Fine sand	5	6
Yellow clay	5	11
Fine brown sand	7	18
Coarse sand and gravel	4	22
Fine sand	6	28
Coarse sand and gravel	13	41
Blue clay	1	42

Much of the area is covered by a wind-blown silt called loess. In parts of the present uplands, especially near the Mississippi River, the drift is mainly loess. Pebbly clay till generally makes up the bulk of the glacial drift below the loess. Within the till, layers and lenses of sand and gravel may occur. A typical log showing the loess, till, and interbedded sand and gravel at Galesburg is given below.

City of Galesburg No. 3 well, sec. 2, T. 11 N., R. 1 E., Knox County, Illinois. Total depth 2473 feet. Elevation 785 feet. Illinois Geological Survey sample set 10725. Drilled by Thorpe Well Company. Studied by M. P. Meyer, 1943-1944.

PLEISTOCENE SERIES	Thick-ness (*ft*)	Depth (*ft*)
Soil, black; silt, noncalcareous, yellowish gray	5	5
Silt, slightly calcareous, yellow	5	10
Silt, noncalcareous, slightly sandy, brown	5	15
Till, noncalcareous, brownish gray to green, pebbly, silty	10	25
Gravel, coarse; sand, yellow, medium; silt, calcareous, gray	10	35
Till, calcareous, sandy, gravelly, dark gray	40	75
Sand, brown, coarse; gravel, fine to coarse	7	82

Sand and gravel, which may have been deposited during more than one glacial stage, occur extensively in parts of northern Rock Island and Henry Counties. These materials were left by glacial meltwaters that carried and deposited rock debris down major valleys (fig. 12). They are more common in thick drift than in thin. The thickness and composition of the layers of sand and gravel can vary significantly within short distances; their presence cannot always be predicted in advance of test drilling.

In general, the areas where the drift thickness is more than 50 feet (fig. 13) are along bedrock valleys (fig. 12). Glacial deposits have completely filled some valleys and partially filled others. Sand and gravel deposits are numerous in the buried valleys.

GROUND WATER

Water Pumpage

The estimated total pumpage (table 1) for ground water and surface water in the region is 33,087,000 gallons per day (gpd). Of this total, 16,556,000 gpd is surface water and 16,531,000 is ground water. The surface water pumpage, which constitutes about 50 percent of the total pumpage, is used to meet the needs of the 112,000 population of Rock Island, Moline, and East Moline. This water is used for industrial as well as domestic and municipal purposes.

County water pumpage varies with population and with the amount of industry located in the county. In total pumpage, Rock Island County ranks first, Knox is second, Henry third, Warren fourth, and Mercer last. Knox County pumps the greatest amount of ground water and is followed by Rock Island, Warren, and Mercer, in that order (table 1). Sources of ground water and water-yielding properties of the rocks are summarized in figure 3.

Public water supplies that have been initiated during the past 80 years are listed in table 2. The decades 1890 to 1900 and 1950 to 1960 were the periods of greatest development, and 12 public water supplies started in each of these periods are still in operation.

When towns draw their public water supplies from bedrock aquifers (table 2) there is a correlation between the population and the depth at which water is obtained. In general, larger towns use deeper sources of water. For example, St. Augustine in Knox County has a population of 201 and obtains water from the Keokuk-Burlington Limestone at shallow depths. The 24 towns that take water from the Hunton Megagroup (Devonian-Silurian) average 612 in population. The nine towns taking water from the Galena, Platteville, and Ancell Groups

FIG. 13—Thickness of drift (from Piskin and Bergstrom, 1967).

have an average population of 1,500. The average population of towns whose water comes from the Hunton Group, Glenwood-St. Peter (Ancell) and other deeper formations is 7,340.

Drift Aquifers

The water-bearing properties of the glacial drift vary and reflect the wide range of physical properties of the glacial deposits. The main aquifers of the drift are beds of sand and gravel, which occur in bedrock valleys, at the base of glacial till sheets, or interbedded between tills.

The distribution of sand and gravel aquifers 15 or more feet thick is shown in figure 14. This figure is adapted from a map of the sand and gravel aquifers of Illinois that was prepared from subsurface data in 1965 by Kemal Piskin of the Illinois Geological Survey.

Piskin defined buried aquifers as those 15 or more feet thick and covered by 10 or more feet of overburden. Surficial aquifers were defined as those 15 or more feet thick and covered by less than 10 feet of overburden. Although all known water-bearing materials that meet these criteria were included in figure 14, other deposits may exist in the area. Aquifers less than 15 feet thick are known to be present, but were not shown on the map.

The drift aquifers are most commonly associated with bedrock valleys (fig. 12) where the drift is 50 or more feet thick (fig. 13). Because sand and gravel aquifers are more likely to occur in bedrock valleys where the drift is thickest, the areas in which the drift is more than 100 feet thick are shown in figure 14 as having somewhat favorable ground-water conditions. Aquifers other than those mapped may be present. Drift aquifers are generally rare over bedrock uplands where the drift is less than 50 feet thick.

Of the 84 townships within the area of study, 67 contain known drift aquifers at least 15 feet thick (fig. 14). These aquifers range from extremely local occurrences, apparently restricted to less than a square mile, to extensive deposits several miles wide and at least 15 miles long.

The map (fig. 14) shows more buried drift aquifers than surficial aquifers in the area. They vary considerably in lateral extent and occur at various depths. Surficial aquifers are less common in the study area because many of the valleys are small and do not contain permeable deposits as thick as 15 feet. However, surficial aquifers are extensive in such large buried valleys as the Green River Lowland of northern Henry County and the Ancient Mississippi Valley of northern Rock Island County. These valleys were glacial drainageways along which thick and extensive layers of sand and gravel were deposited, and they are probably the only areas in which yields of several hundreds of gallons of water a minute are available from sand and gravel. Only low (sometimes a gallon or two per minute) to moderate yields can be obtained from the drift in most of the region. Test drilling would commonly be required to determine the presence of permeable deposits. Where water-yielding deposits of sand and gravel are very thin or absent, shallow wells of the dug type may obtain water from the drift by penetrating the loess and underlying till. In areas of less than 50 feet of drift (fig. 13), some wells reach the top of bedrock and obtain water that seeps through gravelly material at the base of the drift.

Water from sand and gravel aquifers is usually not highly mineralized, but it is fairly hard and occasionally has a high iron content, as shown by the following analyses of water from the four municipalities that obtain supplies from sand and gravel aquifers (Hanson, 1950, 1958, 1961) (p. 35).

The relatively high mineralization of the water at Geneseo and Yates City is probably due to the proximity of Pennsylvanian bedrock.

Shallow Bedrock Aquifers

The term "shallow bedrock aquifers," as used in this report, refers to water-yielding rocks above the Maquoketa Group. The

Water Analyses for Four Municipalities

	Galesburg	Geneseo	Roseville	Yates City
Total dissolved minerals (ppm)	210	840	235	329
Hardness (as $CaCO_3$) (ppm)	184	660	148	307
Sulfate (ppm)	—	272.3	45.7	32.5
Chloride (ppm)	3.0	49.0	11.0	6.0
Iron (ppm)	0.5	1.5	0.2	Tr
°F	53.5	52.0	54.8	53.8

rocks belong to the Pennsylvanian, Mississippian, Devonian, and Silurian Systems (fig. 3). The principal aquifers within the shallow bedrock are the Keokuk-Burlington Limestone of Mississippian age and dolomite of the Silurian Niagaran Series.

In most of the region, rocks of Pennsylvanian age are the uppermost bedrock. Relatively impermeable shale is the dominant rock type, but some interbedded sandstones and limestones may be water-yielding, especially where they are fractured or jointed. The sandstones are generally fine grained (Wanless, 1929, 1957) and have low permeabilities. Many are discontinuous in areal extent and quite varied in thickness. Consequently, their potential as a source of ground-water supply is less than that of some of the deeper bedrock units, and their presence at specific drilling sites is difficult to predict.

The Keokuk-Burlington Limestone underlies southern Warren and Knox Counties, or approximately the southern quarter of the area of study (fig. 4), and is the source of water for many farm wells and for at least one public water supply. Wells less than 250 feet deep penetrating the Keokuk - Burlington generally encounter water in fractures, solution channels, or in a zone of chert rubble at the top, directly below the overlying shale. The quantity of water obtainable depends on the distribution and interconnections of the openings but is generally suitable for small to medium supplies. The limestone probably has more water-filled openings where it is not overlain by Pennsylvanian rocks, in western Warren County, for example. Wells drilled within a few miles of the northern limit of the Keokuk-Burlington may encounter thin sections of limestones that will not yield water for extended periods of pumping. The northern limit of the limestone is probably somewhat more complex than is shown in figure 4.

An analysis of water from the Keokuk-Burlington Limestone at Kirkwood showed 503 parts per million (ppm) total dissolved minerals, 434 ppm hardness (as $CaCO_3$), 21.6 ppm sulfate, a trace of chloride, and 1.7 ppm iron (Hanson, 1950). Water is more highly mineralized to the southeast, where the formation is deeper. In Peoria County, water in the Keokuk-Burlington contains 8,000 ppm total dissolved minerals, with 4,500 ppm chloride (Horberg, Suter, and Larson, 1950, p. 116).

Devonian and Silurian carbonate rocks (limestone and dolomite) underlie most of the area of study. The Devonian limestones, which are thickest on the west side of the area, are generally tight and contain few water-bearing openings. They are generally less pure than, for example, the Niagaran, and solution openings are not abundant. At least one exception to this generalization is at Seaton, Mercer County, which obtains its supply from the Devonian at a depth of 244 feet. However, a thick bed of sand and gravel that overlies the Devonian there may contribute to the reservoir capacity of the limestone.

The dolomite of the lower Silurian Alexandrian Series also has a relatively poor potential for ground-water supply, being commonly argillaceous and having few openings. The Alexandrian Series underlies all of the area except for a very restricted area in southwestern Warren County (fig. 4).

The dolomite of the Niagaran Series is the most dependable shallow bedrock aq-

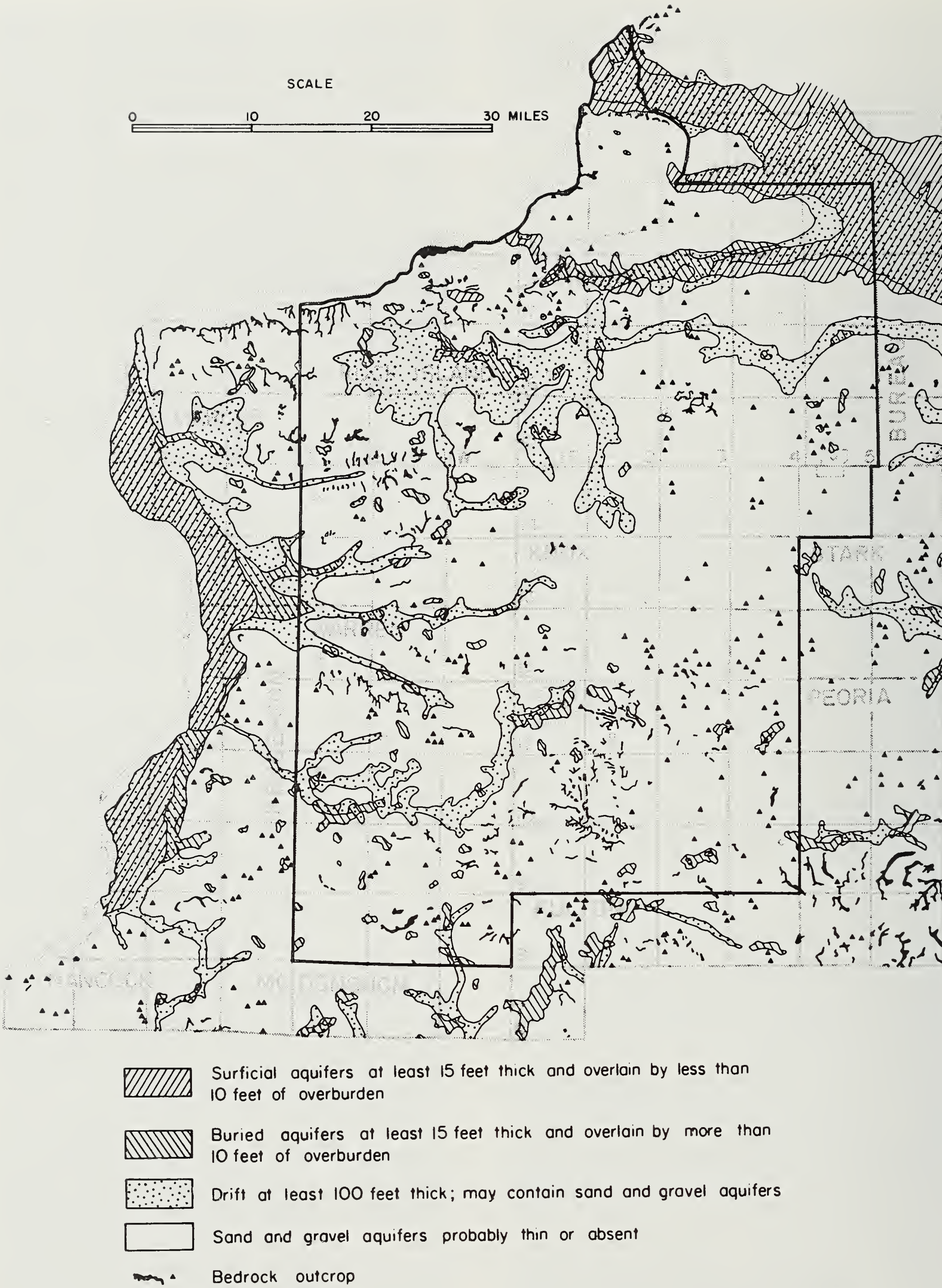


FIG. 14—Sand and gravel aquifers (adapted from a map by Kemal Piskin).

uifer in this area. The upper 100 to 150 feet of the Niagaran is generally well creviced and water is available for small to medium supplies from wells that range from about 400 feet deep in the north to 750 feet deep in the southeast corner of the region. Most of the 25 public water supplies listed in table 2 that take water from the Hunton Megagroup (Devonian-Silurian) depend upon the Niagaran. Wells are commonly cased through the Pennsylvanian and Mississippian shales and are left open in the limestone and dolomite. Many wells that terminate in Ordovician and Cambrian sandstones are left uncased in the Devonian and Silurian rocks, from which some contribution to the total yield is obtained.

The distribution of the Niagaran and that of the Keokuk-Burlington Limestone, the other main shallow bedrock aquifer, complement each other. The Niagaran, which is well developed in the central and northern part of the study area, is thin or absent southwest of central Warren County. The Keokuk-Burlington is thin in central and northern Warren County where it overlaps the Niagaran, and it thickens to the southwest where the Niagaran is absent. Thus, at least one of the two rock units is present throughout the study area. Yields of the Niagaran rocks are usually greater than those of the Keokuk-Burlington.

Csallany and Walton (1963, table C) presented the results of pumping tests on wells open to the Devonian, Silurian, and Maquoketa. For 15 tests in the area of study, the average pumping rate was 95 gpm; the rate of three tests was more than 150 gpm; and two tests pumped less than 30 gpm. The average adjusted specific capacity per foot of penetration was 0.017 gpm per foot of drawdown; in three tests it was more than 0.030 gpm; and in six it was less than 0.010 gpm. If an average adjusted specific capacity of 0.017 gpm per foot of drawdown per foot of penetration is assumed, a well that penetrated 250 feet into the aquifer and was pumped to produce 50 feet of drawdown would yield 212 gpm.

Csallany and Walton (1963, table B) also gave the results of pumping tests on wells open only to the Silurian. For 21 tests in the area of study, the average pumping rate was 109 gpm; in four tests it was more than 200 gpm, and in three it was less than 30 gpm. The average adjusted specific capacity per foot of pentration was 0.034 gpm per foot of drawdown; in three tests it was more than 0.040 gpm, and in six tests less than 0.010 gpm. If the same penetration and drawdown figures used above and a specific capacity of 0.034 gpm are applied, a well in the Silurian would yield 424 gpm. According to these data, wells open only to the Silurian have a higher average pumping rate, maximum pumping rate, and average adjusted specific capacity per foot of penetration than do the wells open to the Devonian, Silurian, and Maquoketa. Perhaps the best explanation for this seeming paradox is the relation between the geographic distribution of wells in the study area and the distribution of the Devonian and Silurian strata. Most of the wells reported in Csallany and Walton's table B (Silurian only) are in the northern and eastern parts of the area where the relatively impermeable Devonian is thin or absent and where the Niagaran Series of the Silurian is thickest. In contrast, many of the wells in Csallany and Walton's table C are in the southern and western parts of the area where the thickness relations are reversed. In general, the Silurian appears to be more permeable where the overlying Devonian is thin or absent.

Water analyses for 21 public water supplies obtained from the Devonian-Silurian (Hunton) rocks were compiled, by county, from Hanson (1950, 1958, 1961). The analyses show that water is least mineralized in Rock Island and Henry Counties where the rocks are shallowest, intermediately mineralized in Mercer County, and most highly mineralized in Knox County where the rocks are deepest, as illustrated by the averages shown on page 40.

The mineralization of water from the Devonian-Silurian rocks not only increases to the southeast in the study area but

Analyses of Water from Devonian-Silurian Rocks

	Rock Island	Henry	Mercer	Knox
Public water supplies	5	3	6	7
Total dissolved minerals (ppm)	329	361	687	1233
Hardness (as $CaCO_3$) (ppm)	184	248	197	94
Sulfate (ppm)	13	14	83	178
Chloride (ppm)	21	3	86	228
Iron (ppm)	0.5	0.5	1.4	1.2

continues to increase southeast of Knox County. Horberg, Suter, and Larson (1950, p. 116) found that the Silurian rocks in Peoria County yielded water with a total dissolved minerals count of 3,500 ppm.

Deep Bedrock Aquifers

The term "deep bedrock aquifers," as used in this report, refers to those below the Ordovician Maquoketa Group. In these aquifers sandstones are the major water-yielding beds, but some creviced dolomites also yield water. Shales within the Maquoketa Group, Glenwood–St. Peter Sandstone, and Eau Claire Formation retard water movement and are not sources of water for wells. The shales sometimes cause problems in well construction because of their tendency to cave. The shales of the Maquoketa Group and the lower unit of shale and chert (Kress) in the Glenwood–St. Peter Sandstone frequently must be cased off. Other Cambrian and Ordovician rocks are usually left uncased.

DOLOMITE AQUIFERS

The major dolomite units are the Galena, Platteville, and Prairie du Chien Groups and the Eminence and Potosi Formations. Of the 23 recorded test holes and wells that end in the Galena or Platteville, at least 13 were structure or oil tests. Csallany and Walton (1963, table D) gave specific capacity data for five pumping tests conducted on three wells in the Galena-Platteville in the area of study; data for eight pumping tests on six wells in the Galena-Platteville located in adjacent counties also are given. The average adjusted specific capacity per foot of penetration for the nine wells is 0.029 gpm per foot of drawdown and the range is from 0.003 to 0.073 gpm. The average pumping rate for the 13 tests is 145 gpm. If the average adjusted specific capacity is 0.029 gpm/ft in a well that penetrates 250 feet of the Galena-Platteville and the well is pumped to produce 50 feet of drawdown, the yield would be 237 gpm.

Several wells in the area have ended in the Prairie du Chien, and a few in the Rock Island area have ended in the Potosi Dolomite and Franconia Formation. Most of the wells that end in dolomite units below the Glenwood–St. Peter Sandstone are thought to draw more water from the New Richmond Sandstone and the Momence Sandstone Member of the Eminence Formation than from the dolomite. Not enough quantitative information is available for an adequate analysis.

The quality of the water obtained from the few wells that may draw most of their water from one of the major dolomite units below the Maquoketa has not been directly determined. By inference, water in the Galena-Platteville is more highly mineralized than water in the Glenwood–St. Peter.

SANDSTONE AQUIFERS

The sandstone aquifers include the Glenwood–St. Peter, the New Richmond Sandstone, the Momence Sandstone Member of the Eminence, the Ironton-Galesville Sandstone, and the Mt. Simon Sandstone. As many wells that penetrate these units are uncased below the Maquoketa, the yield of individual aquifers is difficult to determine.

Glenwood–St. Peter Sandstone

The Glenwood–St. Peter Sandstone is the most widely used sandstone aquifer in the area. At least 88 wells or test holes pentrate part or all of it, making it one of the main sources of large ground-water supplies in the region.

Within the area where the middle shale (Kingdom Member) of the Glenwood–St. Peter is well developed, five test holes and/or wells of record apparently do not penetrate the shale but terminate in the upper sandstone (Starved Rock Member). The upper sandstone thins to the north up the regional slope and possibly wedges out.

Data are not available on the water-yielding capacity of the upper sandstone unit or on the quality of its water, as most wells that reach the upper sandstone are also open to higher formations.

Within the area where the middle shale is well developed, several wells are open to both the major sandstone units of the Glenwood–St. Peter, as well as to higher beds. Well No. 1 at Carbon Cliff, Rock Island County (Appendix, log 6), is considered representative of wells that draw from both sandstones and the higher beds. The well was cased to 623 feet, leaving it open to the Galena-Platteville and Glenwood–St. Peter. After 20½ hours of pumping at 608 gpm, the drawdown was 135 feet (Hanson, 1958). The water contained 1,707 ppm total dissolved solids, 450 ppm hardness (as $CaCO_3$), 310 ppm sulfate, 630 ppm chloride, and 0.6 ppm iron.

Water from a well at Viola where only the lower 98 feet of the Platteville and 127 feet of Glenwood–St. Peter were uncased contains 1,104 ppm total dissolved solids, 210 ppm hardness (as $CaCO_3$), 297.7 ppm sulfate, 260 ppm chloride, and 0.1 ppm iron (Hanson, 1950). The difference in water quality between the Carbon Cliff and Viola wells supports observations that the water quality of Glenwood–St. Peter wells improves as the Galena-Platteville section is cased out, which indicates that water in the Galena-Platteville is more highly mineralized than water in the Glenwood–St. Peter.

The pumping rates for thirteen wells open to the Galena-Platteville and Glenwood–St. Peter (Walton and Csallany, 1962) average 247 gpm; the average adjusted specific capacity of these wells is 3.10 gpm/ft. The pumping rates for tests for wells open only to the Glenwood–St. Peter average 202 gpm; the average adjusted specific capacity of these wells is 2.50 gpm/ft. Obviously, the Galena-Platteville section contributes a significant quantity of water to Glenwood–St. Peter wells.

New Richmond, Eminence, Potosi, and Franconia Formations

The New Richmond Sandstone and the dolomite and sandstone of the Eminence Formation (fig. 3) probably yield some water to all wells that penetrate them. In the southern part of the study area, both units are more dolomitic and therefore probably less productive.

A well at East Moline State Hospital (Rock Island County, sec. 20, T. 18 N., R. 1 E.) apparently terminates in the New Richmond. Many wells in the Rock Island area penetrate sandy dolomite and dolomitic sand a short distance below the New Richmond that average 60 feet thick. This unit has been called the Jordan Sandstone but is now called the Eminence Formation in this area. Buhle (1935, p. 19) reported that water was always found in the formation, commonly from crevices in the dolomite, and that its piezometric surface in the Rock Island area stood at about 560 feet above sea level. Some wells reaching this unit had natural flows of more than 200 gallons a minute.

At least 12 wells in the study area penetrate the Eminence but do not reach the underlying Ironton-Galesville. Nine of the 12 extend from 17 to about 100 feet into the Potosi Dolomite and three partially penetrate the Franconia Formation.

The city of Silvis, Rock Island County, obtains water from a well that terminates in the Potosi Dolomite at a depth of 1,680 feet. The well is cased to 672 feet. It was tested for 5 hours at 600 gpm and had a drawdown of 177 feet (Hanson, 1958). The water contains 1,456 ppm total dissolved solids, 347 ppm hardness (as $CaCO_3$), 338.4 ppm sulfate, 453.0 ppm chloride, and 0.4 ppm iron.

The Franconia Formation probably contributes little of the ground water pumped in the region, as it is generally fine grained and has low permeability. Buhle (1935, p. 14) reported that water from East Moline's old well No. 2, which was finished in the Franconia, was relatively low in total hardness, calcium, magnesium, and chloride, and he attributed the low mineral content to natural softening produced by glauconite in the Franconia.

Ironton-Galesville Sandstone

The Ironton-Galesville Sandstone underlies the entire study area and constitutes the primary source of ground water for large supplies. Although the unit becomes more dolomitic to the south of the area, it is essentially a uniform, clean sandstone.

Many of the wells that extend to the Ironton-Galesville are similar to the City of Abingdon No. 2 (Appendix, log 7). The well is cased to 1,441 feet (through the Glenwood–St. Peter), and, when test pumped in 1946 for 1 1/3 hours at 460 to 485 gpm, had a drawdown of 11 feet (Hanson, 1950). Water from the well contained 1,324 ppm total dissolved solids, 349 ppm hardness (as $CaCO_3$), 565.7 ppm sulfate, 160.0 ppm chloride, and 0.7 ppm iron.

Walton and Csallany (1962) presented data for 22 pumping tests conducted on 11 wells open to the Ironton-Galesville Sandstone in the region. Fifteen of the tests were conducted on eight wells open from the Galena to the Ironton-Galesville, and the average pumping rate was 624 gpm, with three rates less than 400 gpm. The average adjusted specific capacity was 22.5 gpm/ft, which is considerably higher than averages for the same interval in northeastern Illinois. The remaining seven tests were conducted on three wells open from the Prairie du Chien to the Ironton-Galesville, and the average pumping rate for these tests was 900 gpm, with all tests above 500 gpm. The average adjusted specific capacity was 37.7 gpm/ft, with two tests below 30.0.

Mt. Simon Sandstone

The Illinois Geological Survey has records of two water wells and two deep oil tests that reach the Mt. Simon Sandstone in the region. The water wells are located in sec. 17, T. 14 N., R. 3 W., Mercer County, and in sec. 8, T. 17 N., R. 1 W., Rock Island County. The oil tests are in sec. 8, T. 17 N., R. 1 E., Rock Island County, and in sec. 30, T. 16 N., R. 1 E., Henry County. Two other wells extend into the lower sandy zone of the Eau Claire but probably do not enter the Mt. Simon. The deep test in Henry County (Appendix, log 1) fully penetrates the Mt. Simon, whose thickness at that site is 1,255 feet; the Mt. Simon penetration of the other wells ranges from 28 to 960 feet.

The original well drilled for Aledo in the late 1880's penetrated the Mt. Simon about 5 feet to a total depth of 3,114 feet. A generalized log of the well (Appendix, log 8) was compiled from the drillers log and samples of well cuttings.

Leverett (1899, p. 622) reported that water from the well "was not markedly saline until a depth of 2,620 feet had been reached. The temperature is 68° F." The depth Leverett mentions approximates the top of the Mt. Simon.

An analysis of water from the well showed the following constituents (Hanson, 1950)—total minerals, 432.787 grains per gallon (7,424 ppm); calcium sulfate, 88.280 grains (1,511 ppm), and sodium chloride, 269.874 grains (4,627 ppm).

Because the water was so highly mineralized, the well was back-filled to a depth of 1,450 feet into the New Richmond Sandstone. The well was cased only to the top of bedrock. In 1907, water from this well was reported to have a total mineral content of 2,592 ppm; in 1918, 1,746 ppm; and in 1932, 1,673 ppm.

An oil test by Moline Oil and Gas Company reached the top of the Mt. Simon at a depth of 2,300 feet in sec. 8, T. 17 N., R. 1 E., Rock Island County. A water sample from a depth of 3,100 feet contained 5,501 ppm total dissolved solids, 1,224 ppm total hardness (as $CaCO_3$), 922 sulfate, and 2,224 ppm chloride (Buhle, 1935, table 1). A well drilled for the Tri-City Railway Company in Prospect Park. Moline (sec. 8, T. 17 N., R. 1 W., Rock Island County) is reported to have penetrated 28 feet of Mt. Simon Sandstone below a depth of 2,340 feet, but was abandoned because the water was highly mineralized (Buhle, 1935, p. 6).

Although data on the quality of the ground water of the Mt. Simon are limited, they all suggest that the water is too highly mineralized for most purposes.

Recharge and Ground-Water Movement

Ground water moves by the force of gravity from places of intake or recharge to lower places of discharge. The energy ground water possesses at a certain place by virtue of its level or pressure is called the *hydraulic head*. Ground water moves in the direction of lower head, and this is the hydraulic gradient.

Although the principal movement of ground water is laterally through permeable beds, movement transverse to beds takes place where head decreases in that direction. For example, if water above a relatively impermeable confining bed is under greater head than the water in the confined aquifer below, the water above will percolate into the lower aquifer; if it is under less head, the water in the lower aquifer will escape upward.

Data on head relations—as expressed by water levels under nonpumping and pumping conditions—are necessary for determining the pattern of ground-water movement. However, reports on water levels, hydraulic gradients, hydraulic properties, or water quality of individual deep aquifers in the area of this report have been few because most deep wells are open to, and obtain water from, several aquifers. In some deep wells the Devonian-Silurian rocks also are left uncased, further reducing the opportunity for obtaining specific data on the deep aquifers. Because of the lack of data, the hydrology of the deeper rocks is not well known, and generalizations on ground-water movement, recharge, and discharge must be somewhat speculative.

More is known about the general movement of ground water in the shallow rocks —the glacial drift and Pennsylvanian, and, in the western and northern parts, the Mississippian, Devonian, and Silurian. Water in these rocks probably circulates in shallow flow systems, entering the ground from precipitation in upland areas, then percolating downward and flowing laterally to discharge along drainage lines. It is known from studies of areas in northeastern Illinois (Williams, 1966) that the paths of water movement in the drift are often extremely shallow and short. Commonly, water enters the drift along stream divides and discharges a few hundred to a few thousand feet away along minor tributary or major streams.

As the upper bedrock formations are mainly dense shales and limestones, most water enters them through joints and fractures. The pattern of ground-water movement through the Pennsylvanian rocks and the New Albany Shale is complex. Some water enters fracture zones on narrow uplands and discharges in nearby valleys through permeable beds or at the tops of tight shale beds. Where the uplands are broad and flat, much of the water entering the fractures percolates downward to lower formations, and only along the sides of the uplands does water move toward the valleys. The shales also confine underlying permeable beds and permit the development of artesian pressures. For example, in the southern third of the area (fig. 5), the Pennsylvanian shales confine the Keokuk-Burlington rocks, and in the southern two-thirds of the area the New Albany Shale confines the Devonian-Silurian limestones and dolomites.

Recharge to the Keokuk - Burlington Limestone occurs in the southern third of the area where the limestone crops out or immediately underlies the drift or where the overlying Pennsylvanian rocks are thin or cap broad flat uplands.

The Silurian and Devonian carbonate rocks (Hunton) are close to land surface only in the northern part of the area (fig. 5), where they are recharged on the uplands and discharge water along the main river valleys—the Mississippi, Rock, and Green. In the southern two-thirds of the area the Hunton is more than three or four hundred feet deep and has Pennsylvanian shales and the New Albany Shale above it. Here water percolates downward to the Hunton and moves laterally toward the Illinois River. This is suggested by a few data that show declining head between the Keokuk-Burlington Limestone and Silurian dolomite in southern Knox County, increasing mineralization of water in the Silurian in a southeasterly direction (Hanson, 1950, 1958, 1961), and increase of head between the Keokuk-Burlington and Silurian along the Illinois River (Udden, 1912, p. 94).

The Maquoketa Group retards downward percolation of water from the shallow aquifers and confines the water in the deep aquifers. It thus separates the two systems, but does not entirely seal them.

FLOW IN THE DEEP AQUIFERS

Water level data on individual deep aquifers (Hanson, 1950, 1958, 1961) are inadequate to determine the head relations below the Maquoketa Group. In the early days of development—mainly before the early 1900's—flowing wells were commonly obtained from rocks below the Maquoketa Group where land surface was below an elevation of about 630 feet above sea level. The flow commonly increased as the Galena-Platteville, Glenwood–St. Peter, New Richmond, Eminence, and Ironton-Galesville rocks were successively penetrated. In a few wells, measurements indicated that the hydraulic head increased downward, but in many others it is not known whether increased head or penetration of more permeable rocks, or both, caused the increased flows. In the adjacent Peoria region, flowing wells from the Silurian, Galena-Platteville, and Glenwood–St. Peter rocks were obtained below a surface elevation of about 600 feet (Udden, 1912, p. 94).

With the introduction of pumping, artesian head declined, particularly in the Glenwood–St. Peter Sandstone, the most heavily developed aquifer. By the 1920's, the artesian head had fallen well below a 600-foot elevation at most places (Hanson, 1950, 1958, 1961). Buhle (1935) reported that the Jordan Sandstone (Eminence) then still supported flowing wells at some locations in the Rock Island area. Head in formations as deep as the Ironton-Galesville Sandstone has continued to decline as a result of pumping. Today artesian head in the aquifers below the Maquoketa increases downward, but this is largely because there has been less pumping of the deeper aquifers.

From limited data (Hanson, 1950, 1958, 1961, and Udden, 1912), analogy with northeastern Illinois (Suter et al., 1959), and theoretical models presented by Freeze and Witherspoon (1967), it is postulated that head relations before pumping were such that water below the Maquoketa Group flowed mainly laterally through the permeable sandstone aquifers and that there was some discharge upward through the Maquoketa into the Silurian rocks. The Freeze and Witherspoon (1967) models suggest that some discharge of deep flow systems probably occurs in major valleys, such as the Mississippi and Illinois, but not in minor valleys. Water level data in the Illinois Valley at Peoria (Udden, 1912, p. 94) tend to confirm this. There is no indication that under natural conditions any of the area in study was a recharge area for the deep rocks.

Water was probably recharged to the deep aquifers from topographically high areas in the northern part of Illinois where the Maquoketa Group and younger relatively impermeable rocks are absent and the Galena-Platteville Group and older rocks crop out or underlie the glacial drift (Suter et al., 1959, p. 59). Movement of water from the recharge area in general probably followed the regional bedrock structure; that is, it moved southward and southeastward, with some convergence of flow toward the main drainages. Recharge and discharge areas were thus separated by several scores of miles, with wide areas of deep, essentially horizontal flow between.

Under pumping conditions today, some of the water in the deep aquifers is being diverted toward wells, some water in the underlying formations is being induced to flow upward in pumping centers, and some water in the shallow aquifers is being drawn downward. Some lateral flow doubtless continues, as does upward discharge along the major drainage lines.

A further consequence of the prevailing ground-water flow systems and the variable permeabilities of the rocks is the pattern of mineral quality variation in the ground water. Water percolates downward and then moves laterally, becoming more mineralized with depth. Where the movement is through Pennsylvanian or New Albany rocks, which have low permeabilities, the water becomes fairly highly mineralized with depth, particularly with chlorides and sodium, because there has been little dilution or flushing of even the very soluble salts.

In the deep aquifers, where water is for the most part flowing laterally along gently dipping beds, the water becomes more mineralized to the south and southeast and eventually becomes of a quality that makes it unsuitable for human use. Because the permeabilities of the Ordovician and Cambrian sandstones are higher than those of the shallower Mississippian and Devonian-Silurian carbonates, a greater quantity of fresher water has flowed through the sandstones, flushing the very soluble salts, like the chlorides, farther down dip. Less soluble salts, such as the sulfates, constitute a major part of the mineralization of these waters. The underflow in the deep aquifers has therefore produced less mineralized, sulfate-bearing waters under more mineralized, chloride-bearing waters.

Where water from the deep aquifers is escaping upward into the Silurian rocks, as it possibly does along the Illinois River, the level of mineralization may be intermediate—one with less mineralization than the Keokuk-Burlington rocks but more than the Galena-Platteville and Glenwood–St. Peter rocks— and the amounts of chlorides and sulfates present may be somewhat similar.

Ground-Water Conditions by County

HENRY COUNTY

Permeable sand and gravel aquifers occur in glacial drift from 100 to more than 300 feet thick in the Green River Valley and the buried Ancient Mississippi Valley in the northern townships of Henry County (fig. 14). Geneseo obtains water from wells 15 to 65 feet deep in these aquifers adjacent to the Green River. A 65-foot well was tested at a rate of up to 605 gpm with a drawdown of 10.4 feet after 6¼ hours of pumping (Hanson, 1950). The sand and gravel aquifers mapped in the northern townships are the most favorable sources of large ground-water supplies in the county. Elsewhere, sand and gravel deposits are thin and scattered and are most likely to be found in the tracts of thicker drift.

Pennsylvanian rocks are the uppermost bedrock in most of the county, attaining a maximum thickness of about 300 feet. Sandstones and fractured limestones and shales in the Pennsylvanian yield sufficient water for domestic supplies in some places. The chances of obtaining a well in Pennsylvanian rocks with a yield exceeding 15 gpm are poor (Csallany, 1966, p. 36).

Dolomite of Silurian age, ranging in thickness from about 250 feet in the south to more than 400 feet in the north, is the main source of domestic ground-water supplies and the source of municipal supply at Andover, Annawan, Bishop Hill, Colona, and Orion. The upper 125 feet of the rock is the most favorable water-yielding zone. Wells in the Devonian-Silurian must be projected for depths ranging from 400 feet in the northern part of the county to 700 feet in the southern part.

The Glenwood–St. Peter Sandstone is the next important aquifer below the Silurian dolomite. Along with the Devonian-Silurian and Galena-Platteville Dolomite, it provides municipal water supply for Alpha, Atkinson, Cambridge, Galva, and Woodhull. Wells to the Glenwood–St. Peter are some 1,500 feet deep at Galva and Kewanee.

The deepest aquifer penetrated in the county is the Ironton-Galesville Sandstone at Kewanee, where it occurs at a depth of about 2,450 feet. Water development during the past 80 years at Kewanee has shown that wells drilled to the Glenwood–St. Peter commonly yield about 200 gpm of water with approximately 1,200 ppm total dissolved minerals, whereas wells to the Ironton-Galesville yield 600 to 900 gpm of water with about 1,700 ppm total dissolved minerals (Hanson, 1950).

KNOX COUNTY

Water-yielding sand and gravel deposits are rare beneath the upland, where the drift is less than 50 feet thick and bedrock crops out intensively (fig. 13). Some sand and gravel aquifers that are mainly suitable for small supplies occur along the valley of Cedar Creek at and west of Galesburg and along Spoon River in the southern part of Knox County (fig. 14). Testing is necessary to locate suitable well sites. For example, at Yates City a test a mile east of the village revealed a deposit of sand and gravel some 30 feet thick overlying bedrock at a depth of 85 feet; the lower 11 feet, when developed, yielded 100 gpm with 2 feet of drawdown (Hanson, 1950).

The Pennsylvanian rocks range from about 50 to 300 feet thick in the county and yield a few small ground-water supplies locally. Most wells go through them to penetrate deeper aquifers. The Keokuk-Burlington Limestone is a fairly dependable aquifer for farm supplies in the southern third of the county, with wells ranging from about 250 to 350 feet deep. Water in the Keokuk-Burlington is probably quite highly mineralized in the southeastern corner of the county.

The Silurian dolomite is better creviced than the Keokuk-Burlington Limestone and, being deeper, is capable of somewhat greater yields. It and the overlying Devonian limestone are the source of seven public water supplies in the county (table 2). Wells range from about 600 to 900 feet deep. The Silurian thickens from less than 90 feet to almost 300 feet between the southwestern and northeastern corners of the county, whereas the Devonian limestone averages about 90 feet.

The deep bedrock aquifers, principally the Glenwood–St. Peter and Ironton-Galesville, are sources of large ground-water supplies and are developed at Abingdon and Knoxville; they formerly were used at Galesburg. Wells to the Ironton-Galesville are about 2,500 feet deep. A log and water analysis from the Abingdon well are given in log 7 of the Appendix.

MERCER COUNTY

Deposits of sand and gravel are extensive in Mercer County only along the Mississippi River. They are thin and discontinuous in some of the tributaries of the Mississippi in the nine eastern townships of Mercer County considered in this report (fig. 14). Locally, within the areas where the drift exceeds 200 feet thick, sand and gravel deposits suitable for drilled wells are present.

Most farm wells are finished in the Devonian-Silurian rocks and a few in Pennsylvanian sandstones or fractured shales, limestones, or coal. Six public supplies (table 2) are obtained from the Devonian-Silurian rocks, with wells ranging from 250 to 650 feet deep and averaging 400 to 500 feet deep.

The Glenwood–St. Peter Sandstone is the deepest aquifer in use for public water supply. It is penetrated by wells 1,200 and 1,280 feet deep at Aledo and Viola. The Ironton-Galesville Sandstone, which could be penetrated in wells about 2,400 feet deep, represents a possible additional source of ground water.

ROCK ISLAND COUNTY

Sand and gravel aquifers along the Mississippi River are thin and limited in areal extent in most of Rock Island County because the river south of Cordova flows through a rock gorge. North of Cordova, in the two northern townships, extensive and fairly thick sand and gravel deposits occur along the ancient course of the Mississippi. This tract extends eastward (fig. 14) to the bend of the Illinois River at Hennepin in Putnam County; it is one of the main areas of favorable but undeveloped ground-water resources in the state. In the sandy tract north of Cordova, alluvial deposits, containing considerable sand and gravel, are from about 40 to more than 200 feet thick.

Sand and gravel deposits along the Rock River are thin and scattered. The glacial drift thickens to more than 100 feet in the southeastern townships and contains local beds of sand and gravel.

Some domestic wells obtain small supplies of water from sandstone, coal, or fractured shale in the Pennsylvanian rocks that attain a maximum thickness of about 100 feet. However, most wells are drilled through the Pennsylvanian and Devonian rocks and are completed in the Silurian dolomite. The Silurian is reached at depths ranging from a few feet in the northern part of the county to about 400 feet in the southeastern corner. Water-filled fractures are most likely to occur in the upper 125 feet of the dolomite, but the overlying Devonian limestone and the lower part of the Silurian dolomite are commonly tight and not water-yielding. Five public water supplies are obtained from the Silurian and Devonian rocks.

Of the deep aquifers, the Glenwood–St. Peter, Eminence, and Ironton-Galesville have supplied water for municipal and industrial purposes in Rock Island County, with wells from 1,100 to 2,100 feet deep. At present, only Carbon Cliff and Silvis have deep wells; the larger cities obtain public supplies from the Mississippi River.

WARREN COUNTY

Thin sand and gravel deposits in Warren County are penetrated at many places in the glacial drift, which attains a maximum thickness of about 135 feet. The thicker deposits occur along belts bordering Henderson and Cedar Creeks (fig. 14). Roseville, with three wells 20 to 35 feet deep, has the only public water supply in the county drawn from the glacial drift.

Wells in the Pennsylvanian rocks are common in the eastern townships of the county where sandstones yield water in the depth range of 35 to 150 feet. In the southern two-thirds of the county many wells are finished in the Keokuk - Burlington Limestone. The average thickness of the Keokuk-Burlington is 100 feet, and the range is from 5 to 155 feet; the average depth to the top of the limestone is about 140 feet. Where the Keokuk-Burlington is absent, wells generally go to the Silurian dolomite. In the southwestern quarter of the county where the Niagaran rocks are absent, wells are either completed in the Keokuk-Burlington or in the deeper aquifers.

Alexis and Kirkwood have wells that reach the Glenwood–St. Peter Sandstone at depths of about 1,200 feet, and the Monmouth wells are finished in the Ironton-Galesville Sandstone at depths of about 2,400 feet.

CONCLUSIONS

1. A variety of ground-water sources are available within the Rock Island, Monmouth, Galesburg, and Kewanee area, including drift aquifers, shallow bedrock aquifers, and deep bedrock aquifers. They provide about half of the total water pumped in the area, the remainder being drawn from surface sources.

2. Drift aquifers are generally thin and of limited extent in most of the area of study. Where they do occur, many are suitable for small water supplies.

3. Thick deposits of permeable sand and gravel in the drift occur only in northern Rock Island and Henry Counties and are favorable sources for large water supplies.

4. The most widespread aquifers for small to medium water supplies are the Niagaran Series dolomite and the Keokuk-Burlington Limestone.

5. The principal bedrock sources of water for industrial and municipal supplies are the deep sandstone aquifers. The most favorable units are the Glenwood–St. Peter Sandstone and the Ironton-Galesville Sandstone, which appear to be usable in the entire area, although their water quality is less favorable in the southeast. Water in the Mt. Simon Sandstone is probably too highly mineralized for most uses.

6. Water in the drift and shallow bedrock is recharged locally, whereas water in bedrock aquifers below the Maquoketa Group probably comes mainly from recharge areas tens of miles to the north and northeast.

7. Pumping has lowered the artesian head considerably in the deep bedrock aquifers, particularly in the Glenwood–St. Peter Sandstone. In the last two decades there has been a marked reduction in pumping from the deep aquifers in the Tri-Cities and at Galesburg as more supplies have been developed from the Mississippi River or shallow aquifers.

8. In the future it is likely that smaller municipalities will go to deeper aquifers as their water needs increase, and larger municipalities will obtain supplies from the Mississippi River or from areas of favorable gravel aquifers.

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APPENDIX

1. E. A. SOUTH NO. 1

Sample study log of the E. A. South No. 1 well, SW SW SW sec. 30, T. 16 N., R. 1 E., Henry County, Illinois. Total depth 3863 feet. Elevation 803 feet. Illinois Geological Survey sample set 41427. Drilled by Ralph E. Davis, October 1961. Described by T. C. Buschbach, 1964.

	Thickness (*ft*)	Depth (*ft*)
QUATERNARY SYSTEM		
PLEISTOCENE SERIES		
Till, silty, yellowish gray, leached	50	50
Till, calcareous, yellowish orange to olive, oxidized, sandy at base	113	163
PENNSYLVANIAN SYSTEM		
Shale, calcitic, dark gray, carbonaceous, pyritic, hard; coal; abundant sand, medium, uncemented, angular, pyritic	27	190
Shale, silty, gray, brittle, micaceous; siltstone, argillaceous, gray; some coal and weak, dark gray shale; a little sandstone, light yellowish gray, fine, firm	75	265
DEVONIAN SYSTEM		
CEDAR VALLEY FORMATION		
Dolomite, very silty, light brownish gray to light greenish gray, very fine	15	280
Limestone, dolomitic, light grayish brown, gray, white, very fine to lithographic, partly fossiliferous; chert at 330-340′	100	380
WAPSIPINICON FORMATION		
Lost circulation; no samples	20	400
SILURIAN SYSTEM		
NIAGARAN SERIES		
No samples	18	418
Dolomite, light gray, fine to medium, crystalline, porous, vuggy (reef rock)	72	490
Dolomite, as above, pale yellowish gray	10	500
Dolomite, light gray to pale yellowish gray, fine to medium, crystalline, porous, vuggy in part	100	600
ALEXANDRIAN SERIES		
Dolomite, light gray to light yellowish gray, fine to medium, partly porous; trace of glauconite	40	640
Dolomite, cherty, light yellowish gray to light gray, fine; trace of glauconite; a few weak, light green argillaceous streaks	23	663
ORDOVICIAN SYSTEM		
CINCINNATIAN SERIES		
MAQUOKETA SHALE GROUP		
BRAINARD SHALE		
Shale, silty, dolomitic, greenish gray; few dolomite streaks 690-700′	75	738
FORT ATKINSON DOLOMITE		
Dolomite, silty, argillaceous, gray, fine; interbedded shale, silty, greenish gray; shale increases toward base	17	755
SCALES SHALE		
CLERMONT MEMBER		
Shale, silty, dolomitic, greenish gray to grayish brown; interbedded dolomite in 1-2″ beds and irregular nodules	75	830
ELGIN MEMBER		
Shale, silty, dolomitic, dark brown to grayish brown; dolomite streaks, brown, fine; depauperate zone at base and top	40	870

CHAMPLAINIAN SERIES		
GALENA GROUP		
WISE LAKE FORMATION		
Dolomite, grayish buff, gray mottled, fine, pyritic; 1″ calcite crystals	1	871
Dolomite, buff, medium to fine, porous, partly vuggy; thin reddish brown shale partings; numerous gastropods 945′ to base	107	978
DUNLEITH FORMATION		
Dolomite, cherty, buff, fine to medium; rare thin shale partings	126	1104
GUTTENBERG FORMATION		
Dolomite, reddish buff, coarse; dark reddish brown shale partings 1/16 - 1/4″ thick at 3 - 6″ intervals; 3″ green shale at base	7	1111
Wavy interbeds of dolomite, brown, coarse; dolomite, gray, fine; shale, reddish brown	7	1118
PLATTEVILLE GROUP		
Limestone, brown, lithographic, dense; dolomite, brown, fine; shale partings, reddish brown; beds of *Strophomena* and ½″ dark brown shale at base	14	1132
Dolomite, calcitic, grayish brown, very fine	5	1137
Dolomite, calcitic, cherty, grayish brown, very fine (chert in 1-4″ nodules)	11	1148
Limestone, brownish gray, very fine; some gray "birds eye" mottling; chert nodules	4	1152
Limestone, grayish brown, very fine to coarse, fossiliferous, cherty in upper 10′; thin dark brown to dark gray shale partings	18	1170
Dolomite, calcitic, grayish brown to brown, partly gray mottled, fine; limestone, dolomitic, brownish gray, very fine	21	1191
ANCELL GROUP		
GLENWOOD FORMATION		
Sandstone, dolomitic, fine, fucoidal; many irregular dark gray argillaceous laminae; 6″ green shale at base	4	1195
ST. PETER SANDSTONE		
STARVED ROCK MEMBER		
Sandstone, white, fine to medium, porous, friable, some cross bedding; faint green, argillaceous coloring; 2′ sandy green shale at 1218-1220′	35	1230
KINGDOM MEMBER		
Shale, dark green, hard	9	1239
TONTI MEMBER		
Sandstone, white to light greenish gray, fine to medium, friable, porous, some cross bedding; few 6-8″ streaks of sandstone, white, fine, well cemented	62	1301
KRESS MEMBER		
Shale, bright green; chert pebbles; dolomite fragments	2	1303
CANADIAN SERIES		
PRAIRIE DU CHIEN GROUP		
SHAKOPEE DOLOMITE		
Variable unit of dolomite, partly sandy, partly cherty, light gray to light brownish gray, very fine to fine, slightly glauconitic, partly vuggy; some relict oolitic structure; some thin green shale partings; some thin beds of sandstone, dolomitic, buff, medium; few beds of dolomite, coarse to medium, porous; chert, chalky to tripolitic, occurs as nodules and as replacement networks; includes thin stringers of sandstone in places; some nearly vertical fracturing 1430′ to base	193	1496
Dolomite, silty, light grayish brown, very		

fine; interlaminated with green shale	1	1497
Dolomite, light grayish brown, very fine ...	7	1504
Dolomite, sandy in lower part, light brown and light grayish brown, mottled, fine, crystalline, vuggy; calcite crystals in some vugs...	6	1510

NEW RICHMOND SANDSTONE

Sandstone, dolomitic, medium to fine, moderate sorting, subrounded to subangular, slightly friable; dolomite, sandy, light gray to light pinkish gray, very fine; shale partings, green; chert, sandy, white, chalky, oolitic; slight oil stain in vug at 1532′	47	1557

ONEOTA DOLOMITE

Dolomite, light grayish brown to light gray, very fine; thin glauconitic films	3	1560
Dolomite, slightly sandy, brownish gray, medium to fine, crystalline, partly vuggy; some calcite and drusy dolomite in vugs; little chert..	20	1580
Dolomite, cherty, light brownish gray, fine to medium, crystalline, partly vuggy ..	8	1588
Dolomite, white to pale yellowish brown, medium, porous; some soft white silica in vugs; a trace of shale, light green, brittle	22	1610
Dolomite, cherty, light gray to light brownish gray, medium to fine, porous, slightly pyritic; some green shale partings; pale orange chert 1670-1680′; dolomite, very coarse at 1690-1700′	90	1700
Dolomite, light brownish gray, medium to fine, porous, slightly glauconitic; dolomite, pink, coarse, hematitic; trace of sand..	20	1720
Dolomite, cherty, light gray to light yellowish brown, fine; some thin contorted beds of green shale	20	1740
Dolomite, partly cherty, light yellowish brown to brown, fine to coarse, porous, vuggy; calcite; quartz crystals, drusy dolomite, and white siliceous powder in vugs; few green shale partings; some partial chert replacement ..	29	1769

CAMBRIAN SYSTEM

CROIXAN SERIES

EMINENCE FORMATION

Dolomite, sandy, grayish brown to light brownish gray, fine to medium; chert, oolitic, sandy, white; thin stringers of sandstone, light green, medium, cemented with white, chalky silica; thin stringers and blebs of green clay	11	1780
Sandstone, dolomitic, white, medium, moderately sorted, subrounded, coherent .	10	1790
Dolomite, sandy, light brownish gray, fine to medium; chert, sandy, oolitic, white; some calcite, pyrite, and green shale	26	1816

MOMENCE SANDSTONE MEMBER

Sandstone, siliceous, dolomitic, white to tan, medium, poorly sorted	14	1830

POTOSI DOLOMITE

Poor samples — lost circulation	10	1840
Dolomite, slightly sandy, light grayish brown, fine, very slightly glauconitic at top; a little drusy quartz and dolomite. Lost circulation at 1865′	60	1900
Dolomite, light grayish brown, a little light pink mottling, fine,		

slightly glauconitic; drusy quartz; some pyrite and calcite associated with lost circulation zone at 1960′	96	1996
FRANCONIA FORMATION		
Dolomite, slightly sandy, light gray to pink, fine, glauconitic	49	2045
Sandstone, dolomitic, slightly argillaceous, greenish gray, fine, very glauconitic, friable, porous; shale partings, gray, brittle; a few streaks of dolomite, silty, sandy, brownish gray, very fine, slightly glauconitic	102	2147
Dolomite, light buff, fine, crystalline; dolomite, silty, sandy, gray, very fine, slightly glauconitic	13	2160
Shale, silty, green, brittle to weak, micaceous, slightly glauconitic; sandstone, silty, grayish orange, very fine, glauconitic	17	2177
IRONTON-GALESVILLE SANDSTONE		
Dolomite, sandy (some coarse), light grayish brown, medium, very glauconitic (some coarse); vague spherules; few beds of sandstone, dolomitic, medium, light grayish brown, well cemented, poorly sorted, glauconitic	23	2200
Sandstone, slightly dolomitic, white, medium, poorly sorted, friable; few streaks of sandstone, dolomitic, light brown, white, pale pink, medium to fine, well cemented	106	2306
EAU CLAIRE FORMATION		
Sandstone, slightly dolomitic, light gray, fine, friable, glauconitic; some dark gray shale partings; little dolomite, silty, light gray to light pinkish gray, very fine	34	2340
Sandstone, silty, light gray to pink, very fine to fine, friable, glauconitic, fossiliferous; shale, silty, green, gray, weak to brittle	38	2378
Siltstone, grayish orange to light gray, coarse, compact, glauconitic, micaceous; shale, greenish gray, brittle, micaceous	72	2450
Interbedded siltstone, as above, and shale, greenish gray, red, brittle, micaceous	38	2488
Sandstone, silty, dolomitic, light gray to grayish orange, very fine, compact, glauconitic, micaceous, fossiliferous; a little conglomerate of dolomite, yellow, pink, white, coarse, glauconitic; fossil fragments; some sand	27	2515
Sandstone, as above; grades to coarse siltstone; shale, silty, greenish gray, brittle, micaceous; conglomerate, as above	35	2550
Sandstone, dolomitic, light gray to light brown, fine, friable to compact, fossiliferous, pyritic, partly sooty; some shale, silty, greenish gray, brittle, micaceous	50	2600
MT. SIMON SANDSTONE		
Sandstone, white to light gray, medium to fine, poorly sorted, friable, rounded, slightly sooty	44	2644
Sandstone, white, medium, poorly sorted, rounded, friable; some very coarse grains	76	2720
Sandstone, pink, medium, poorly sorted, friable, hematitic; some pale yellow grains; shale, red, green	90	2810

	Thickness (ft)	Depth (ft)
Sandstone, silty, argillaceous, pink, pale yellow, medium to fine, very poorly sorted, friable; little shale, silty, red, very micaceous, brittle	40	2850
Sandstone, pink to red, medium to coarse, friable, poorly sorted, partly hematitic; some pale yellow grains...	100	2950
Sandstone, white, pale yellowish gray, medium, poorly sorted, rounded to subangular, friable, clean, porous; some broken grains	50	3000
Sandstone, white, fine, moderate sorting, subrounded, friable to well cemented by silica	190	3190
Sandstone, white, pink, fine (some medium), subrounded, friable to slightly friable, some red ferruginous bands	220	3410
Sandstone, red, pink, little white, medium, subangular, friable to slightly friable, poorly sorted, hematitic ...	190	3600
Sandstone, white, pink, fine to medium, subangular, moderately sorted, slightly friable; some beds hard, well cemented by silica, low porosity	75	3675
Sandstone, pink, fine to medium, moderately sorted, slightly friable, low porosity. ..	45	3720
Sandstone, pink, medium, subrounded, moderately sorted, friable, porous	30	3750
Sandstone, white, pink, red, medium to fine, rounded, friable; soft white to pinkish clay — possibly drilling mud	75	3825
Sandstone, arkosic, coarse, red, pink, rounded and angular quartz fragments; very little feldspar ..	15	3840
Sandstone, arkosic, red, hematitic; quartz fragments, as above, but increased feldspar	15	3855
PRECAMBRIAN		
Granodiorite, coarse, dark; pink and red feldspar, clear quartz, considerable biotite .	8	3863 (total depth)

2. CITY OF KEWANEE NO. 4

Partial sample study log of the City of Kewanee No. 4 well, sec. 4, T. 14 N., R. 5 E., Henry County, Illinois. Total depth 2501 feet. Elevation 843 feet. Illinois Geological Survey sample set 52353. Drilled by Varner Well Company. Described by J. E. Brueckmann, September 1965.

	Thickness (*ft*)	Depth (*ft*)
ORDOVICIAN SYSTEM		
PRAIRIE DU CHIEN GROUP		
SHAKOPEE DOLOMITE (165′)		
Dolomite, light brownish gray, pink, extra fine, slightly sandy in part; little chert, white, clear, partly oolitic	65	1535
Shale, green, weak, slightly sandy in part; little dolomite and chert	10	1545
Dolomite, buff, light brownish gray, extra fine, slightly sandy in part; little chert ...	45	1590
Dolomite, grayish red, little gray to light brownish gray, extra finely crystalline ...	10	1600
Dolomite, light brown to buff, extra fine to very fine, slightly sandy in part	35	1635
NEW RICHMOND SANDSTONE (65′)		
Sandstone, fine to coarse, incoherent; dolomite, light brownish gray, extra fine, partly silty and clayey (buff); trace of white chert	30	1665
Dolomite, extra fine, light gray to white; trace of sand; trace of white chert	15	1680
Sandstone, medium to coarse, dolomitic, in-		

	Thickness (ft)	Depth (ft)
coherent; dolomite as above	20	1700
ONEOTA DOLOMITE (170′)		
Dolomite, white, light yellowish gray, partly fine to medium, little coarse, very cherty (light gray to yellowish gray)	25	1725
Dolomite, as above; trace of chert	70	1795
Dolomite, light brownish gray, fine to coarse; little chert	20	1815
Dolomite, as above, cherty	35	1850
Dolomite, as above, pink, slightly glauconitic	20	1870

3. VILLAGE OF NORTH HENDERSON NO. 1

Partial sample study log of the Village of North Henderson No. 1 well, sec. 26, T. 13 N., R. 1 W., Mercer County, Illinois. Total depth 710 feet. Elevation 760 feet. Illinois Geological Survey sample set 30260. Drilled by Peerless Service Company. Described by G. H. Emrich, 1957.

	Thickness (*ft*)	Depth (*ft*)
DEVONIAN SYSTEM		
CEDAR VALLEY FORMATION		
Dolomite, light brown to grayish brown, very fine to fine, crystalline	10	335
No sample	5	340
Dolomite, silty, light brown to buffish gray, very fine to fine, crystalline	20	360
Dolomite, very argillaceous, silty, light buffish gray to buffish gray, very fine	40	400
Dolomite, calcareous, brown, very fine to fine, crystalline	5	405
WAPSIPINICON FORMATION		
Limestone, slightly dolomitic, slightly silty, buff to brownish buff, very fine to fine, crystalline	25	430
Limestone, slightly dolomitic, silty, grayish brown to brownish gray, very fine, crystalline	35	465
Limestone, light gray to buff, very fine to extra fine	10	475
Dolomite, slightly silty, buff to brownish gray, very fine to fine, crystalline	20	495
SILURIAN SYSTEM		
Dolomite, white to light gray, little gray, very fine to fine, crystalline	5	500
No sample	5	505
Dolomite, light gray, little gray, very fine to medium, little coarse, crystalline	35	540
Dolomite, light gray, little gray, very fine to fine, little medium, crystalline	25	565
Dolomite, light buffish gray to light gray, very fine to fine, crystalline	35	600
Dolomite, slightly silty, light buff to gray, very fine to fine, little medium, crystalline	20	620
Dolomite, light buff to grayish buff, very fine to medium, crystalline	10	630
Dolomite, slightly silty, light grayish buff to gray, very fine to fine, crystalline	10	640

4. MARGARET BLOOMER NO. 1

Partial sample study log of the Margaret Bloomer No. 1 well, sec. 16, T. 9 N., R. 3 E., Knox County, Illinois. Total depth 619 feet. Elevation 630 feet. Illinois Geological Survey sample set 9840. Drilled by Larson and Swanson. Adapted from study by M. P. Meyer, 1943.

	Thickness (*ft*)	Depth (*ft*)
MISSISSIPPIAN SYSTEM		
KEOKUK-BURLINGTON LIMESTONE		
Chert, dolomitic, calcareous at base, slightly glauconitic, light gray	12	200
Dolomite, very cherty, calcareous at base, silty, light gray to light buff, very fine	15	215
Limestone, very cherty, dolomitic, glauconitic, silty, light gray, medium to coarse, crinoidal	15	230

	Thickness (ft)	Depth (ft)
Limestone, very cherty, dolomitic, light gray to light buff, medium to coarse, crinoidal	10	240
Dolomite, very cherty, calcareous, glauconitic, light buff to light gray, very fine	20	260
Limestone, very cherty, dolomitic, light buff to light gray, medium to coarse	20	280
Limestone, cherty, dolomitic, light gray, fine to medium	30	310
MISSISSIPPIAN AND DEVONIAN SYSTEMS		
NEW ALBANY SHALE GROUP		
Shale, dolomitic, green, brittle; little sandstone, dolomitic, light gray, very fine, compact at top	15	325
Shale, slightly dolomitic, light gray; little siltstone, dolomitic, light gray, compact	55	380
Shale, slightly dolomitic, light gray and brown variegated; spores; little siltstone	50	430
Shale, light gray, weak	10	440
Shale, brown; spores	30	470
Shale, light gray; trace siltstone	15	485
Shale, dark brown, brittle; spores	34	519
Shale, light gray, weak, pyritic	33	552

5. VILLAGE OF WOODHULL NO. 2

Partial sample study log of the Village of Woodhull No. 2 well, sec. 30, T. 14 N., R. 2 E., Henry County, Illinois. Total depth 1369 feet. Elevation 824 feet. Illinois Geological Survey sample set 554. Drilled by J. P. Miller Well Company. Studied by L. E. Workman, 1925. Description published by Wanless (1929, p. 187).

	Thickness (*ft*)	Depth (*ft*)
PENNSYLVANIAN SYSTEM		
Shale, silty, slightly calcareous or noncalcareous, medium gray, micaceous, very soft	45	145
Shale, calcareous, dark gray to black, noncarbonaceous, nonlaminated, tough or soft	15	160
Shale, noncalcareous, medium gray, soft; with coal	5	165
Underclay, light gray, soft, micaceous; contains many pieces of yellowish brown, granular, fine-grained limestone	10	175
Underclay, silty, light gray, soft, micaceous	15	190
Shale, dark gray, soft; some black laminated, brittle.	5	195
Shale, silty, light yellowish gray, brownish gray, and dark gray, soft; with coal at base	30	225
Shale, silty, dark gray to black, micaceous; with streaks of light gray, argillaceous siltstone	25	250
Underclay, silty, medium brownish gray, soft, micaceous; coal, shaly, impure, dull; siltstone, argillaceous, light gray; and dolomite, argillaceous, brown, tough	15	265
Shale, dark and light gray, micaceous, poorly laminated; locally calcareous and concretionary	65	330
Sandstone, calcareous, medium gray, pyritic; grains fine to medium, poorly sorted.	5	335
Shale, dark and light gray	5	340
Sandstone, calcareous, well cemented, dense, pyritic	5	345
Shale, silty, dark and medium gray, nonlaminated	15	360
Sandstone, dolomitic, pyritic; grains are fine, clear, angular or rounded, frosted	5	365

6. VILLAGE OF CARBON CLIFF NO. 1

Sample study log of the Village of Carbon Cliff No. 1 well, sec. 4, T. 17 N., R. 1 E., Rock Island County, Illinois. Total depth 1105 feet. Elevation 575 feet. Drilled by Cliff Neely, 1951. Studied by D. W. Baird.

	Thickness (*ft*)	Depth (*ft*)
QUARTERARY SYSTEM		
PLEISTOCENE SERIES		
"Sand and gravel"	90	90

	Thickness (ft)	Depth (ft)
SILURIAN SYSTEM		
Dolomite	350	440
ORDOVICIAN SYSTEM		
MAQUOKETA GROUP		
Shale and dolomite	215	655
GALENA AND PLATTEVILLE GROUPS		
Dolomite	330	985
GLENWOOD–ST. PETER SANDSTONE		
Sandstone, some shale	40	1025
Sandstone	75	1100

7. CITY OF ABINGDON NO. 2

Sample study log of the City of Abingdon No. 2 well, sec. 33, T. 10 N., R. 1 E., Knox County, Illinois. Total depth 2583 feet. Elevation 747.5 feet. Illinois Geological Survey sample set 703. Drilled by Thorpe Bros. Studied by L. E. Workman, 1927.

	Thickness (*ft*)	Depth (*ft*)
QUARTERNARY SYSTEM		
PLEISTOCENE SERIES		
Drift	35	35
PENNSYLVANIAN SYSTEM		
Shale, limestone, and sandstone	155	190
MISSISSIPPIAN SYSTEM		
Limestone	120	310
MISSISSIPPIAN and DEVONIAN SYSTEMS		
Shale	240	550
DEVONIAN SYSTEM		
Limestone, shaly	60	610
Limestone	20	630
SILURIAN SYSTEM		
Dolomite	90	720
ORDOVICIAN SYSTEM		
MAQUOKETA GROUP		
Shale and dolomite	180	900
GALENA AND PLATTEVILLE GROUPS		
Dolomite	310	1210
GLENWOOD–ST. PETER SANDSTONE		
Sandstone, some shale at base	100	1310
Sandstone	100	1410
Sandstone, shale, and chert	5	1415
SHAKOPEE DOLOMITE		
Dolomite	255	1670
NEW RICHMOND SANDSTONE		
Sandstone and dolomite	60	1730
ONEOTA DOLOMITE		
Dolomite	250	1980
CAMBRIAN SYSTEM		
EMINENCE-POTOSI DOLOMITE		
Dolomite	260	2240
FRANCONIA FORMATION		
Dolomite and sandstone	230	2470
IRONTON-GALESVILLE SANDSTONE		
Sandstone	110	2580
EAU CLAIRE FORMATION		
Dolomite	2	2582

8. CITY OF ALEDO NO. 1

Sample study log of the City of Aledo No. 1, sec. 17, T. 14 N., R. 3 W., Mercer County, Illinois. Total depth 3114 feet. Elevation 739 feet. Drilled by George Dickson. Drillers log interpreted by T. E. Savage, 1889.

	Thickness (*ft*)	Depth (*ft*)
QUARTERNARY SYSTEM		
PLEISTOCENE SERIES		
"Clay"	110	110
PENNSYLVANIAN SYSTEM		
"Shale and coal"	52	162
MISSISSIPPIAN and DEVONIAN SYSTEMS		
"Shale"	138	300
DEVONIAN SYSTEM		
Limestone	146	446
SILURIAN SYSTEM		
Dolomite	146	592
ORDOVICIAN SYSTEM		
MAQUOKETA GROUP		
Shale and dolomite	215	807
GALENA AND PLATTEVILLE GROUPS		
Dolomite and little shale	313	1120
GLENWOOD–ST. PETER SANDSTONE		
Sandstone, dolomite, shale	60	1180
Sandstone	60	1240
SHAKOPEE DOLOMITE		
Dolomite	125	1365
NEW RICHMOND SANDSTONE		
Sandstone	105	1470
ONEOTA DOLOMITE		
Dolomite; sandstone	295	1765
CAMBRIAN SYSTEM		
EMINENCE-POTOSI DOLOMITE		
Dolomite	195	1960
FRANCONIA FORMATION		
Shale; dolomite; sandstone	205	2165
IRONTON-GALESVILLE SANDSTONE		
Sandstone	150	2315
EAU CLAIRE FORMATION		
Shale	142	2457
EAU CLAIRE FORMATION AND MT. SIMON SANDSTONE		
Sandstone	657	3114 (total depth)

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